# AUSTRALIAN FIELD ARCHAEOLOGY
# A GUIDE TO TECHNIQUES

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# Contents

# Preface

This book is the successor to the two editions of the well known and much used 'Manual No. 4' edited by D. J. Mulvaney. The first edition was published by the Australian Institute of Aboriginal Studies in 1968 and reprinted in 1969; the second edition appeared in 1972. Stocks of both editions of the old 'Manual No. 4' are now exhausted.

In its original form the work consisted of ten chapters, and in the second edition those chapters were repeated with the addition of an eleventh. In the preface to the second edition of 'Manual No. 4' the editor acknowledged that there had been criticisms of the book, not only because of 'important omissions' but also because there was 'a lack of unity in contributions, in that some are intended for a general audience, while others relate to specialist laboratory needs'. The editor was of the opinion, however, that the scope of the book was justified.

Ten years have passed since that time and in those ten years there have been many changes in Australian archaeology. It is now virtually impossible to put together a book on this subject without being criticised for 'important omissions' and, in an effort to reduce these omissions in number, I have increased the size of this book to 19 chapters. There have been changes also in the readership at which the book is aimed. The previous editions seemed to have aimed mainly at 'the interested non-professional' and I very much hope that this book will continue to serve that part of the general public who have an active concern for Australia's prehistoric heritage. Since 1972 a new type of reader has appeared, however. There are now increasing numbers of young Australians who have university degrees in prehistoric archaeology and are at the commencement of a professional career in the subject. I have been concerned that both they, and university students still studying for their degree, should have an Australian book that can tell them how to start off in the tasks of, for example, finding sites, analysing a shell midden, or identifying stone implements, and how to do these things in an Australian context. Inevitably, the selection of chapters that I have drawn together has been shaped to some extent by just who I could find who was both expert in a particular field and willing to spend the time writing a chapter of this book. Therefore, the coverage is patchy and has one or two *notable* omissions. General-purpose photography, for instance, has been left out because there are now so many books, and some of them good, that instruct the beginner in the use of the camera—although admittedly books dealing with specifically archaeological photography remain few in number. A more surprising omission, perhaps, is the subject of excavation techniques, which was deliberately excluded by the previous editor because he did not wish to encourage amateur excavation. Nowadays, state legislation generally forbids such excavation, so that it might be considered that the topic should now be included. However, the original emphasis of this book was on field archaeology excluding excavation, in the O.G.S. Crawford sense of field archaeology. Also, in practice, excavation is almost too large a topic to include in such a book as this and, in addition, I was not able to find anyone with sufficiently long experience of specifically Australian excavation who was willing to attempt the writing of such a chapter.

The passage of time and the changes that have come with it are reflected in the changes of title to which this work has been subject. 'Manual No. 4' was originally called *Australian archaeology: a guide to field techniques;* this was changed in the second edition to *Australian archaeology: a guide to field and laboratory techniques.* I have titled this wholly new book *Australian field archaeology: a guide to techniques* because I think that this reflects most accurately the content and coverage. The observant reader will, in fact, notice that only four of the contributors to the second edition of 'Manual No. 4' are to be found amongst the contributors to the new edition. Time brings changes of many kinds.

One development of the last ten years renders the title of this book somewhat inaccurate, however. The title refers to Australian field archaeology although the book is concerned with Australian prehistoric archaeology only. Australian historical archaeologists might feel aggrieved by this but it results mainly from the history of the publication and the necessity to keep the book within a reasonable size. As a person with a foot in both camps, I can only hope that even historical archaeologists will find some of its chapters of use to them. Certainly, the separation of prehistoric and historical archaeology in Australia is one that I would not wish to encourage.

The book opens with a chapter by Sharon Sullivan on how to find sites and what you must do after you have found them. Immediately after this I have placed a chapter by Howard Creamer concerning consultation with those original Australians whose prehistory the book is about. I cannot emphasise strongly enough the necessity for prehistoric archaeologists in Australia to engage in as much consultation and feedback with Aboriginal communities as is possible. To the Aboriginal people who read this book I extend a real invitation to become interested in your own prehistory. It *is* important to you, and those of us who teach this subject in universities want to see more of you becoming archaeologists during the next few years.

No prehistoric archaeologist, or member of the public interested in prehistoric archaeology, can now function in Australia without a working knowledge of the law as it applies to archaeology. As we are perhaps amongst the most over-legislated people in the world, such law is unbelievably complex; not only does each state have its own legislation but some states have more than one set of legislation. We should, therefore, be extremely grateful for Graeme Ward's attempt to review the legislation for the whole country. This was a most difficult chapter to write and in itself is something of a landmark in the discussion of this complex subject.

Douglas Hobbs has ransacked the archaeological surveying literature, and drawn on his own extensive practical experience, in a much-needed attempt to present a basic introduction to surveying techniques that are useful in field archaeology. He has illustrated his chapter himself and has also helped by drawing or redrawing some of the illustrations in other chapters. His chapter is followed by an introduction to terrestrial photogrammetry by John Beaton. This is a subject which is clearly going to grow in importance in Australian archaeology over the next few years. The next chapter, by Ian Johnson, demonstrates, however, that sophisticated and expensive equipment is not always essential when applying photographic techniques to the task of graphic recording. There is a similar do-it-yourself ethos in the next chapter, in which myself and Alan Jones discuss the application of the techniques of aerial photography to Australian prehistoric sites. Then follows a chapter by John Stanley which looks at the practicality of applying magnetic prospection techniques to Australian prehistoric archaeology.

There is then something of a change in emphasis and a number of particularly important aspects of Australian prehistoric archaeological data are examined in some

detail. The first of these is prehistoric art, and John Clegg has written a guide to the recording methods which are now most commonly used. This is followed by an important chapter on geoarchaeology by Phil Hughes and after this is a chapter by Richard Wright on the collection and recognition of stone implements, which is clearly of central importance in Australian prehistoric archaeology. Jeannette Hope's chapter on the recovery and analysis of bone should also be essential reading for everyone interested in Australian prehistoric archaeology. Lastly, in this part of the book, there is a chapter by Sandra Bowdler on midden analysis, which is not only important as a guide to techniques but also an extremely useful summary of the state of the art by someone with extensive experience in this field.

The emphasis of the book then shifts once more to look at dating techniques. First of all Henry Polach, Jack Golson, and John Head have revised a now famous piece of writing concerning the collection and submission of radiocarbon samples and have added to it some discussion of age-reporting practices. This is followed, in the next chapter, by an examination by Henry Polach of the question of radiocarbon recalibration and its applicability to Australia. There is then a chapter by Terry Bell that discusses the use of thermoluminescent dating in Australian prehistoric archaeology.

Finally, there is the question of publication: both the problems of illustration and of writing. Winifred Mumford has revised her chapter from the second edition of 'Manual No. 4' and, as before, has illustrated this almost unique chapter with exemplary skill. Her chapter is followed by a brief chapter by John Clegg, which aims to take some of the fears out of illustration by describing a gadget that should make it a little easier for the beginner. Then, last but by no means least, Peter White's chapter on report writing and publication offers much wisdom that we should all take note of.

It was in 1977 that I was asked to edit this book, and to all the authors I am deeply grateful for both their labours and their patience; I must particularly acknowledge the forebearance of some contributors who wrote their chapters in 1978 and 1979. It is my sincere hope that a new generation of students of Australian archaeology, professional and amateur, will find this book as useful as a previous generation found 'Manual No. 4'.

Graham Connah
*May 1981*

# Chapter 1

# Making a discovery: the finding and reporting of Aboriginal sites

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## HISTORY

> We pursued our route westward, proceeding many miles inland without being able to trace, by a single vestige, that the natives had recently been in these parts. We saw however, some proofs of their ingenuity in various figures cut on the smooth surface of some large stones. They consist chiefly of representations of themselves in different attitudes, of their canoes, of several sorts of fish and animals, and considering the rudeness of the instruments with which the figures must have been executed, they seemed to exhibit tolerably strong likenesses. On the stones, where the natives had been thus exercising their ability in sculpture were several weather beaten shells. The country all around this place was rather high and rocky, and the soil arid, parched and inhospitable. (J. White, *Journal of a Voyage to New South Wales*, 1790.)

This is an early description of an Aboriginal site by an officer of the First Fleet. The writer's urge to record his discovery is still a common one. The same site is regularly rediscovered and reported today. We have a legacy of 200 years of site recording work in Australia, amounting to a sizable amount of data of very varied quality. The material is the result of both casual discovery and purposeful site survey work. By the last quarter of the nineteenth century researchers were actively seeking out sites, recording them in detail, and on the basis of these data, theorising about their relationship to each other, and their significance. These earliest site surveys, such as Etheridge's recording of all known carved trees in New South Wales (Etheridge, 1918) had a number of common factors. They tended to be site-type specific and to be the result of enquiry among the local European population. They were usually surveys of art or ceremonial sites, not of archaeological deposits, since the importance of such sites had not yet been recognised. The main aim of the surveys was the recording of data from sites even then threatened by decay and development. The surveys had some aspects which are common to surveys today; they were by and large instigated or assisted by the government and conducted by public servants, who relied very heavily on the knowledge and assistance of local historians and interested amateurs.

These surveys, plus the constant flow of information on particular sites from the general public, formed the site data banks which were beginning to be compiled in various institutions in the early twentieth century. During this period museum curators stored site data as they arrived, checked out sites on the ground where possible, and based on this information, began systematic surveys for sites in particular areas. With the growth of interest in archaeology in Australia, there was increased recording of occupation sites, especially of rock shelters with deposits and middens. As yet less attention was paid to open sites, except for the more obvious ones such as quarries and stone arrangements. Open campsites were themselves quarried for stone artefacts by collectors but were not recorded in any detail.

The 1960s saw the establishment of the Australian Institute of Aboriginal Studies, which encouraged site survey work throughout Australia leading to a steady increase in data input, and important individual discoveries. The Institute under its first principal, F. D. McCarthy, also began the first attempt at a national site register, gathering together published information on sites, and the data from state and local site record systems. The growing number of university appointments in prehistory led to an increase in regional surveys which sought to describe the cultural history of particular areas, and which contributed to regional site information.

The 1970s have seen a number of significant developments. The new, legally empowered site-protection authorities in each state set up registers of sites, designed forms and procedures for their recording, and began active programmes for site recording. The Australian Institute of Aboriginal Studies established a national site recording programme, funding the new state authorities for specific site recording projects, especially in threatened areas. For the first time particular attention was paid to recording sites of significance to local Aborigines, with Aboriginal participation. The establishment of the Australian Heritage Commission formally recognised the importance of Aboriginal sites as part of the Australian heritage. Aboriginal sites became important evidence in Aboriginal land rights claims. University research in prehistory established the 40 000 year minimum occupation of Australia by Aborigines and demonstrated the importance of preserving a wide range of sites for future study. Many more systematic and sophisticated surveys for sites resulted from the growth of environmental protection legislation which required such surveys as part of the assessment of the effect of development of the environment.

## THE PRESENT SITUATION

Each state now has legislation to protect sites, and as a necessary aid to this purpose houses a data-storage system, consisting of readily retrievable information on each known site. Most data banks, or site registers, are divided into site types, which may vary slightly from state to state. Some distinguish between prehistoric sites and sites of significance to Aborigines. In all systems each site is assigned a number and is stored or cross-referenced in geographic order. In most states the basic map reference is the 1 : 250 000 topographic map, the only one which currently exists for large areas of Australia.

Access to the registers is strictly limited. Site information is usually classified, for access purposes, as open, restricted or closed, depending on the level of confidentiality required. Information on most sites is not automatically available to the general public. There are good reasons

for this: some of the sites are secret/sacred to Aborigines; many are on private land where the present occupiers do not want visitors; all are subject to vandalism if their location becomes widely known without steps being taken to protect them.

To date, site registers are manual but computerisation is an obvious next step presently under consideration. The Australian Institute of Aboriginal Studies is endeavouring to create a national site register, which allows exchange of information on an Australia-wide basis.

The site systems as they stand are frankly the result of a very varied, and completely unsystematic data-collection process, extending over a long period. Relatively few systematic surveys for sites have been conducted in Australia to date. Some site types have been largely ignored because they are relatively inconspicuous while others (such as art sites) have long attracted public interest, and are over-represented in a statistical sense. Whole areas of the country have never been examined at all. New South Wales with 10 000 sites in its register has more recorded sites than any other state, because more researchers have worked this area. However, even in New South Wales, the vast majority of sites have not been recorded.

The site registers are crucial as research and management tools. They are the basis for management decisions about particular sites, and about the effect which development will have on the prehistoric cultural resources in particular areas. Ideally they are used to determine the location and importance of sites which may be affected in any proposed new land use. Their effectiveness depends on data input and as we have seen the quantity and quality of this is respectively scarce and variable. This chapter is intended to assist those who want to add to it, either by reporting a chance discovery of a site, or by conducting a major survey.

## SITES AND THEIR RELATIVE SIGNIFICANCE

A site can be defined as a locus, or concentration, of cultural materials, or a concentration of evidence of human activity. The evidence referred to may be physical or it may be verbal or written—for example, a myth or tradition relating to a particular feature. Within this definition we often distinguish in Australia between sites on the basis of the presumed identity of their creators, e.g., European sites and Aboriginal sites. We are concerned here with the latter. Aboriginal sites in common parlance fall roughly into three groups: occupation sites (areas where people have lived for varying periods of time—for example camp sites); industrial or activity sites (rubbing grooves, quarries, fish traps); art sites (paintings and engravings) and ceremonial/mythological sites. Various combinations of these three types are possible and such divisions are often based on our assumptions of their use. For example a *stone arrangement* may be ceremonial but may have another, unknown, practical use, perhaps as a game hide. Also the division is internally inconsistent in that occupation sites and ceremonial sites are defined by their presumed *function,* whereas art sites are defined by the occurrence of a particular type of prehistoric evidence, its purpose or function being usually unknown.

As mentioned above, for purposes of the site registers, state authorities usually divide sites again into more specific types, generally for ease of access, using terminology in common use. New South Wales for instance uses the following types:

axe-grinding groove
burial/skeletal remains
carved tree
ceremonial/bora ground
contact site
engraving (rock)
fish trap
mia-mia/hut structure
midden/archaeological deposit
natural sacred/mythological site
painting/drawing
quarry/workshop/factory site
rock hole/well
scarred tree
stone arrangement
surface campsite

*Fig. 1*
*The Two Sisters—south coast of New South Wales. This is a mythological site of significance to local Aborigines.*



Because Aboriginal sites occur throughout the whole Australian landscape, large parts of which are rapidly being altered by development, many of them are being or will be destroyed. It is therefore often necessary to assess the importance of particular sites. Judgements about the value of individual sites, or site complexes, are based on an assessment of their importance for research, education or public enjoyment, and their significance to particular Aboriginal groups. Faced with the twin problems of lack of staff to carry out recording work, and the increasing pace of development which is destroying unrecorded sites, state archaeologists are seeking economic methods of building up data on Australia's prehistoric occupation. They are hence turning their attention to systematic surveys, which seek to locate and assess sites in an organised way. Such surveys aim not only to find particular 'important' sites, but to analyse the nature and history of prehistoric occupation in a particular environment zone, with the ultimate aim of predicting the occurrence of

sites in other similar areas; and of using this data as a management tool to preserve a representative sample of sites for the future.

A data system which adequately described the country's prehistoric cultural resources will allow judgements to be made about the importance of particular sites and about consequent management decisions and programmes. However, this approach cannot be applied to sites of significance to Aborigines. A 'sample' approach to such sites is clearly not appropriate, and most state authorities seek to preserve these sites in accordance with the wishes of Aborigines. Nor does the adoption of a sampling strategy cope fully with public and local needs and wishes. It may often be important to preserve sites for public use and enjoyment in a particular area or setting, even though they are not of particular scientific value, and are well represented elsewhere.

Basically, we are dealing with a scarce and irreplaceable resource; and the more information available about it, the better we can curate it. Any site information which adds to the data base is useful. In many areas of Australia we currently know so little about sites that even basic information on their existence and type is valuable. There are, in New South Wales five 1 : 125 000 map sheets on which less than four sites have been recorded officially. Major discoveries are still being made in areas which have been populated by Europeans for 200 years. In the last eighteen months two major, completely undisturbed art sites have been found in the Sydney bush.

Discovering a site may be an unplanned and enjoyable incident in someone's summer holidays, or it may be the result of a carefully planned, purposeful survey. The information is most welcome and valuable in any case. In this chapter I have tried to provide some details which will help people in site discovery and recording, and will make the information they obtain a useful addition to our knowledge of Aboriginal Australia.

## WHERE SITES ARE FOUND

Any undeveloped area of land is likely to have some evidence of Aboriginal activity. The sites are not dotted haphazardly across the landscape; they relate to the living patterns of Aborigines and to their exploitation of the environment. The more we know about these patterns, and the environment, the easier it is to predict where sites might occur. Therefore a good look at the ethnography of the area, and at the environment (geology, climate, natural resources) will often allow the prediction of site occurrence. For example, in areas where water is scarce occupation sites will often be found near permanent or semipermanent water; sites where specialised activities have been carried out will occur where natural resources which relate to these activities, such as suitable rock outcrops, are found. Sites will often be found where there is a concentration of various resources (e.g., plentiful shellfish and fresh water), or on an easy or traditional route through difficult terrain. In other words, people who take an intelligent interest in the bush are most likely to be able to deduce where sites might occur, and to locate them.

## IDENTIFICATION OF SITES

The state authorities (whose titles and addresses are listed at the end of this chapter) have provided a wealth of literature which describes types of sites, their distribution, characteristics, and recognisable features. This information is therefore not included in this paper. Some sites are difficult to recognise or positively identify without experience but in most cases, common sense will assist. If in doubt as to whether you have found a site, you can always check this later with state authorities, provided you have a minimum record. It should also be said that everything that looks unnatural or strange in the bush is not necessarily an Aboriginal site. When assessing a potential site you should try to think of other explanations for it: natural phenomena or European activity, for instance.

## THE LEGAL SITUATION

Legislation covering the protection of sites varies from state to state. If you have any real interest in Aboriginal sites you will ensure that you are familiar with the legislation regarding sites in your area, before you set off to locate them; every state authority can supply you with a guide to the legal requirements. In general all sites are legally protected. You require permission to interfere with them in any way, and all new information on sites should be reported. In some states, some sites are prohibited areas, and a permit is required to visit them (see Edwards (1975) which contains extracts from relevant legislation and see also Chapter 3 in this book).

## WHAT TO DO WHEN YOU FIND A SITE

When you find a site you should report it unless you are reasonably sure it has been reported before. If in doubt you can find this out by contacting the state authority. In most states it is a legal requirement to make such a report. In any case, most people contact the authorities because they wish to know if they have made a new discovery or, alternatively, what past information there is on the site.

Whether you first contact the authority and then return to the site to record it, or take notes on an initial visit will depend on circumstances. In most cases it is safest to assume you will not be returning to the site, and that therefore some note of it should be made on your first trip. The level of detail with which you record a site will depend on your assessment of the site's importance, your circumstances, and your experience and skill.

We cannot predict the use to which the information about a site will be put in the future, and it is not possible to provide for all eventualities. State site record forms aim to provide the minimum basic information, which past experience shows to have been useful to researchers and assessors. If you have access to a state site form it is best to use this; you can get forms, and instructions for their use, from the state authority. Many bushwalkers and other people who are likely to find sites regularly carry such forms with them. However, to be realistic, there is not a high correlation between the occurrence of sites and site record forms. The following notes are intended to help you bring back a reasonable record from the field, when you do not have a site form with you. (See also Coutts & Witter (1977), a useful handbook for site recording. It follows the Victorian system, but has many generally applicable guidelines and information summaries.)

There are two essential requirements of any useful initial site record:

(1) A description of the location of the site, precise enough to allow another person to find the site again using your data. This usually requires a written description and a sketch map.

(2) A description of the site and its setting, which is detailed enough to allow positive future field identification of a particular site and to distinguish it from nearby sites. This usually requires that you describe the site, and note as many distinguishing features as possible.

If you manage a reasonable site description and location you have provided a basic record which can be used, improved, added to, or modified. The two requirements given above are therefore the most important ones to remember. What follows is an expansion of them: a description of how you can add important detail to a site record, if you have the time, patience and energy.

## LOCATION OF THE SITE

Descriptions of the location of a site should, if possible, include the following information.

(1) A written description of how to reach the site with details of the distance from known points and the direction. While you are doing this, try to imagine yourself following your own directions to relocate the site.

(2) A sketch map with distances and with as many recognisable fixed points as possible: roads (labelled), fence lines, natural landmarks, watercourses, and vegetation changes, for instance, can all help a future worker. Compass bearings are often useful.

(3) Land owner/status. If you know this, put it in, it is most useful information for site managers.

(4) Map reference. If you are using a topographic or other map you should be able to give a map reference. Topographic maps usually have instructions about writing map references actually printed on them. But a map reference is not as important as a good location sketch. If the sketch is detailed and accurate a map reference can be derived from it; this is often not the case in reverse, i.e., it is often difficult on a 1 : 250 000 map (5 km to 2 cm), because the scale is too small. The most detailed map available should be used. In many parts of the country excellent 1 : 25 000 maps are now available. You should check for maps with the local or national mapping authority.

(5) Cadastral information. If by any chance you have a cadastral map (one which shows administrative land divisions, e.g., parish, portion, etc.) you can provide this information. Some of the new 1 : 25 000 maps have a cadastral overlay which gives this information.

Many people have real problems locating themselves in the landscape and adequately communicating this information to others. The subject is too large to pursue here, and anyway the only way to learn how to do it is to go out and try. There are, however, some very useful aids if you are interested. An excellent publication which provides basic information on map and compass use is available from NATMAP Sales, Division of National Mapping, P.O. Box 548, Queanbeyan, NSW 2620, or your local outlet (cost, 75c). It is called *Topographic Maps: a guide to map reading*, NATMAP, 1980. Martin & Lotty, *Map and Compass Fundamentals Orienteering*, 1976, is also recommended. It is designed for orienteers but it gives basic data on compass use, topographic terms and features, map reading, and route selection. Each section is followed by an exercise, to which answers are provided, so that progress in understanding can be checked. It is available at some National Trust outlets. Graves' *Travel and Gear*, Bushcraft Handbook No. 9, is also useful. More detailed than either of these is the British Ministry of Defence publication, *Manual of Map Reading*. It is available through Australian Government Publishing Service (AGPS) bookshops.

## DESCRIPTION OF THE SITE

In the site description include, if possible the following details.

(1) A clear description of what the site is, and its major features. For example, if an art site, the colour and types of painting; if a midden, the types of shells and artefacts present.

(2) The extent of the site; for example, the length, depth and height of a rock shelter.

(3) An estimate or count of features; for example, 6 axe grinding grooves, 12 hearths, more than 20 paintings.

(4) A sketch of the site and/or its main features if appropriate; for example, a sketch of the pattern of a stone arrangement.

(5) Local position in relation to surrounding geography; for example, a campsite adjacent to a permanent waterhole.

(6) A brief description of the surrounding environment; for example, forest, woodland, open plain, etc.

(7) A description of the condition of the site and whether it is endangered in any way; for example, by weathering, stock, vandalism, development.

(8) Photographs can illustrate a number of the points if you have a camera handy.

If it is possible you should note these things while you are at the site. Relying on memory is often deceptive. If you have a site form, fill in as much of it as possible *on site*.

## WHAT NOT TO DO AT A SITE

Sullivan (1979) gives a good description of how to enjoy a site. There are also some 'don'ts'. *Don't* wander on to private property in search of sites without contacting the owner or occupier. *Don't* interfere with the site in any way: digging, collecting artefacts, chalking-in art sites, or leaving your own signature are all common forms of vandalism at sites. They are of course illegal for the reason that they are destructive to the site.

People are probably most tempted to collect souvenirs, for their own collection or often to show the state authorities. There are very exceptional circumstances where one would collect from a site—when it is in immediate danger of destruction, for example. But in general collecting is unnecessary and is harmful; it destroys the integrity of the site and makes further study of it more difficult. If you find an unusual or doubtful artefact, sketch it, describe it, photograph it if possible: but leave it *in situ*.

## RETURN TO CIVILISATION

When you return from your trip with the information about a site you should contact the state authority. The registrar will be able to tell you whether the site has been recorded before. If not, or if you have additional information, you will be asked to provide the information, usually by filling in a site form. The information will then be fed into the local site recording system. Your site report will receive a number and be filed appropriately, probably under the relevant 1 : 250 000 map reference. You need not worry that your recording of a site will jeopardise either the site or the landowner's privacy; in fact, quite the opposite: the protection of sites depends in great measure on the state authority being aware of their existence, and as explained earlier the information you provide will not be available to the general public.

## SITE SURVEY

If you are good at locating sites, live in an area where they are prolific, and enjoy bushwalking you may become interested in site survey. Some of the types of survey carried out in Australia to date, which have contributed to the diverse data banks, are surveys based on inquiry and on-the-ground surveys.

### Surveys based on inquiry

These are surveys which rely on information from interested local people for the starting point of their investigations. These can be either site-specific (seeking to locate a particular type of site) or area-specific (seeking to locate known sites in a particular area or region). An example of a site-specific survey of this type is the one in progress in New South Wales to locate and record all known carved trees, using information already in the site system and circularising local authorities, historical societies, etc., seeking further information (Bell, 1979). Fieldwork is then carried out to locate the trees on the ground and record them using this information. The aim is to pinpoint as many extant trees as possible, and thus to enable appropriate management techniques to be implemented for their protection. This type of survey is most appropriate where there are a limited number of sites easily recognisable and spread over a wide geographic area. Clearly, an on-the-ground survey is impractical because these trees are found over about half of New South Wales. The disadvantage is that the trees are recorded in isolation; it is often not possible to relate them to other local evidence of Aboriginal activity and to deduce anything about this relationship. For further examples of this type of survey see also Etheridge (1918) and Campbell (1898).

An example of an area-specific survey based on local information was that carried out over several years by Dr Isabel McBryde in the New England area of New South Wales. She used recorded information and the assistance of interested local people to locate and record sites of all types over a wide geographic area. She recorded many hundreds of sites, and the information collected is the basis for our present knowledge of the prehistory of the area (McBryde, 1974). This type of survey was very appropriate since it was the only feasible method of gaining information of the general nature, type, and distribution of sites over a large, previously unstudied area. Once again, on-the-ground survey was impractical. In a survey of this sort, the most visible and recognisable sites are much more likely to be located, and the result is biased to this extent. Sites with low visibility, and which are not obvious as sites to the ordinary person (e.g., occupation sites), are often not notified. On the other hand, a survey of this type is the only sort which will reveal sites of significance to local Aborigines and other long-term local residents, where there is no archaeological

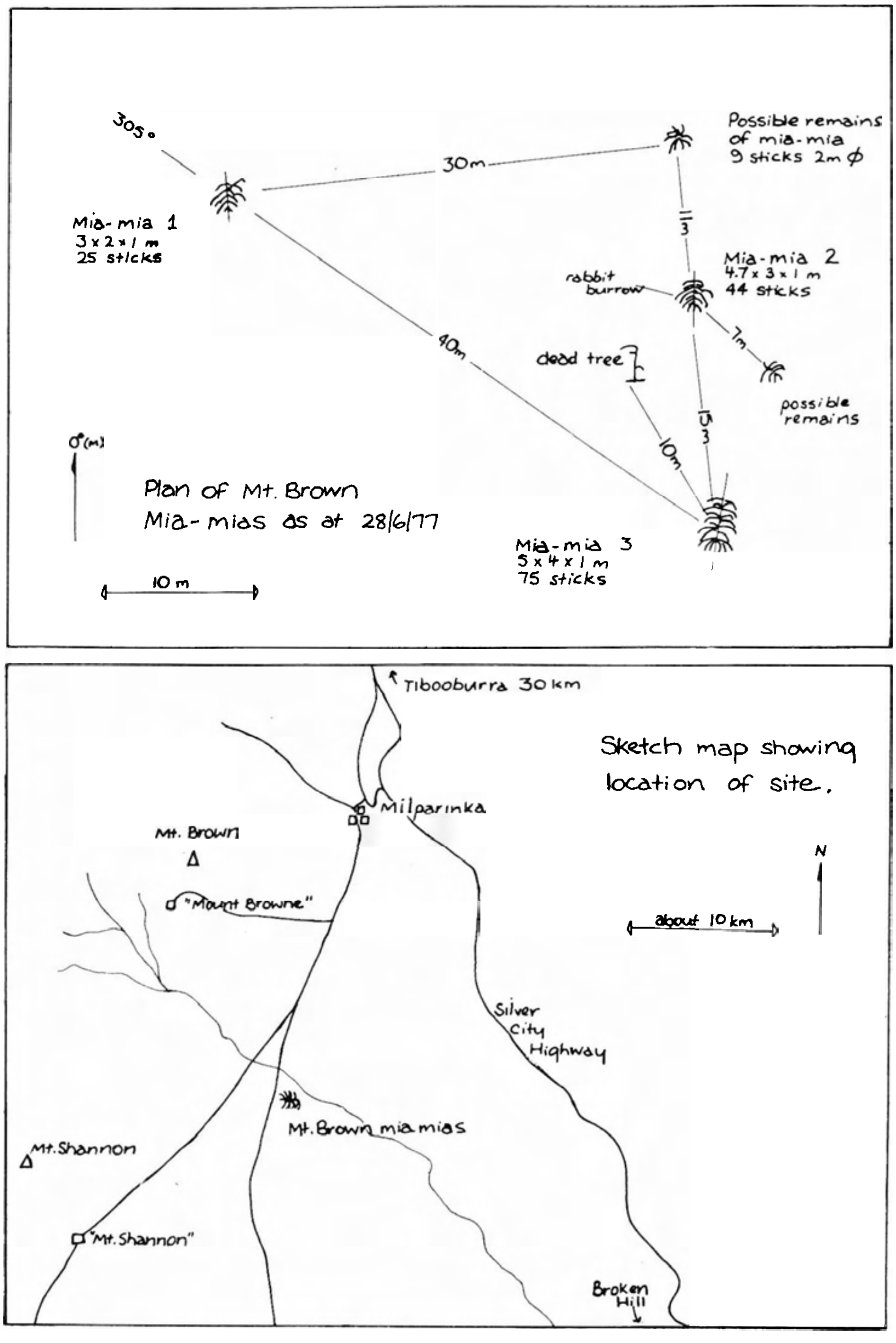



*Fig. 2*
*Simple site plans such as this one (of a mia-mia or Aboriginal house site) are relatively easy to make and provide important additional information.*

evidence of their existence; for example, mythological sites or massacre sites.

### On-the-ground surveys

Usually of a much smaller area, these surveys aim to locate all sites within the area, or all of one type of site within the area. Such surveys are usually conducted to enable a detailed study of the prehistoric resources of an area, for a particular research aim, or often simply to allow an assessment of the resource, as part of environmental assessment procedures. These surveys will usually begin with known information but their aim is to cover the terrain in such a way that all sites, or at least all visible sites, are located. The thoroughness, the techniques employed, etc., depend on the aims of the surveyor and the nature of the area to be covered. An increasing number of such surveys are being conducted; for example, an amateur group has located and recorded all sites in an area of 10 km² of Sydney bushland, and the New South Wales Public Works Department has paid for an on-the-ground survey of the inundation area of a large dam site in the same terrain. The Victoria Archaeological Survey has carried out many such projects: see, for instance, Coutts *et al.* (no date). Such surveys provide us with the first information we have in Australia of site densities in a particular environment and provide data for studying the interrelationship of sites. Enough data of this type may allow archaeological authorities to assess the resource of an environmental zone and predict the occurrence of sites in similar areas. The work can often be detailed and time-consuming. For instance, if you wish to use a survey to assess site density and to predict similar occurrences, then it is as important to know where the sites are not as where they are. Negative evidence such as uninhabited rock shelters and unengraved rock surfaces must be recorded. A detailed recording of an occupied rock shelter can be tedious; a detailed recording of an unoccupied one even more so!

These descriptions of site survey types are simplified. Many variations are possible. For instance, areas too large to survey on foot are often sampled; representative environmental zones within the area are selected and surveyed with the aim of providing data on the whole area. The success of a sampling strategy of this type depends on its design; how closely it resembles the real situation. In Australia the Victoria Archaeological Survey has designed such surveys. In New South Wales State archaeologists will use a sampling strategy to assess the archaeological resources of the 'Five Forests' area of south-eastern New South Wales which is being logged, with subsequent damage to sites. Such a strategy is the only one possible over a very large area.

So discovering a site may be accidental in your summer holidays, or it may be the result of a formal site survey with research aims and a prescribed methodology.

## AIM OF PROJECT

The methods used, the equipment and the results of a survey will depend on its aims. A survey, as we have seen, can take many forms. The aims may be:

(1) To add to the data base by simply recording the sites you find.

(2) To seek out and record a certain type of information; for example, art sites or middens.

(3) To make an inventory of all sites in a particular area.

(4) To gather data for a specific research project; for example, to determine the relationship between art and occupation sites, to establish the density of sites in particular environments, or to analyse the components of a particular art style.

If the aim of the survey is a general data gathering exercise its methods and results will be quite different from those of a survey designed to work out the ratio of one art motif to others in a particular area. Working out the aim can start from two different points. Researchers usually have an aim, or a problem which they wish to solve, and they design a survey to test out their theories. Other workers are more interested in the actual process of survey, in discovering new sites; they generally decide to do a survey and then design it in such a way as to make the results generally useful. You will need to consider some of the common problems in more detail.

## OPERATIONAL SITE DEFINITION

The state authorities provide enticing brochures on site types. However, 10 kilometres from the vehicle at 3 p.m. with a temperature of 30°C in a teatree swamp, things may not seem so clear-cut.

One problem for the surveyor is the operational definition of a site. The whole of Australia is a site in the sense of being a concentration of cultural evidence. A carved tree, a rubbing groove, a hand stencil, are sites; but do we call three flakes, or one indecipherable charcoal scrawl, a site? They are undoubted evidence of Aboriginal occupation, but is it useful to pinpoint and record them? In many parts of the interior of Australia when there is little ground cover it is impossible to step out of a vehicle without treading on a flake. Recording every occurrence is impossible. In another situation, however, three flakes in the dripline of a rock shelter may indicate a substantial occupation deposit. There is no simple answer. Levels of detail in recording will depend on the aim of the exercise: the most important point is to clearly state those aims and the associated methods. To be most useful, however, site records should conform to the minimum requirements of the state system.

## SITE LIMITS

A similar problem arises in defining the limits of a site, and in determining whether it is one site or six. For example, is a row of six rock shelters within 50 metres of each other, all with red hand stencils in them, one site or six? Site registrars have guidelines for this situation, but once again the important point is to describe clearly the locus of activity and to state the decision taken.

## VISIBILITY

Site visibility is a major problem. In large areas of Australia ground cover is such that the chance of finding open sites, except by excavation, is very slim. Some rock shelters which appear sterile on the surface have sizeable deposit; some middens are so well turfed that only erosion or excavation reveals them. Archaeologists can test a potential *localised* deposit such as a rock shelter by excavating but cannot investigate several square kilometres of dry sclerophyll woodland with the same thoroughness. There is no easy solution to this problem. Archaeologists use a variety of techniques in an attempt to gauge the number of hidden sites. They try to conduct surveys when cover is minimal (for example after fires). They study sections exposed by erosion, road building and other construction, and then carry out auger transects or test excavations where this is feasible. It is probably true, however, that a high proportion of open sites remain undiscovered in areas where there is substantial ground cover. Sites of significance to Aborigines are also often

invisible to Europeans without specific information being provided by the traditional owners or guardians.

## CONSULTING THE STATE AUTHORITY

These problems and other local complications should be known to you, in so far as it is possible, before you begin work. At this stage it is important to consult the state authorities. This is because:

(1) The state site registrar can tell you which sites have been recorded in a particular area, which areas have been surveyed, which areas are suitable for survey and could be most usefully surveyed, and in general what work has already been done on the area/topic you propose.

(2) The state site registrar can also tell you the legal requirements for survey, the preferred recording methods, and other obligations.

(3) The state authority may also be able to assist with maps, equipment, field expenses, and logistical help, if the project seems useful.

(4) In most cases it is appropriate that you consult local Aborigines concerning the survey. Some of the sites you plan to record may be sacred or significant to them, and they may have certain rules concerning them. They may also have information which is valuable or may wish to participate in the survey. The state authorities all employ Aboriginal site recorders or rangers and can assist you in your contact with local Aboriginal groups.

## METHODS

When you have consulted the appropriate authorities, and have decided on the aims and area for survey, you can work out your methods. Probably the most important thing to aim for is consistency. Methods should be simple enough for your personnel to use and flexible enough for unexpected field conditions, but above all they must be consistently adhered to, to allow the gathering of data which yourself or others can use for comparative studies. In other words, deciding to change radically the method of survey, the site form, or some other important component of the survey, halfway through the work may not be advisable. If may make the data acquired in the first part of the survey useless, or non-comparable with later data.

To work out suitable methods you obviously need information about such matters as the methods used in previous similar surveys and terrain, the resources available, and the known data concerning the ethnography and history of the area. You will also need some specialist information to deal with particular sites; for instance, if your survey is to include scarred trees you need to examine the literature on how to tell an Aboriginal scar from a natural one; if you are surveying coastal middens the characteristics of wave re-working in such middens would be a useful piece of information (see for instance Hughes & Sullivan, 1974). Here again, the state authorities can assist, by directing you to useful information and relevant experts.

## EQUIPMENT

This will depend on the aims and methods of survey. You will need light portable equipment, the minimum required for the project. This will normally include:

(1) site forms (either the state site form or one especially designed with extra information for the purpose of your survey);

(2) clipboard, pens, pencils, spare paper, etc.;

(3) camera, if possible, and scale;

(4) locational aids, which could include:
   (a) compass
   (b) best available topographic maps
   (c) air photographs
   (d) special-issue maps
   (e) cadastral maps.

Air photographs, used properly, are very useful tools for accurately locating sites. A portable stereoscope is necessary to use them properly. Air photomosaics are often useful when good scale topographic maps are not available. They consist basically of standard air photographs put together in a mosaic, with an adjusted scale. Also, special larger scale maps are sometimes available, brought out by relevant authorities: for example maps of national parks or of areas to be developed. Such aids are obtainable (borrow or purchase) from your local mapping authority or lands department.

## PERSONNEL AND LOGISTICS

The scope of the survey will depend to some extent on personnel available. Enthusiasm and perseverance are important qualities in any group carrying out survey work. Any survey operating over a period of time will have a certain number of drop-outs and new people joining. This is one reason why methods should be clearly worked out, and written down, to ensure consistency despite changing personnel.

It is always better to have personnel working in groups than individually, and conversely to make individuals within the group responsible for a particular job. Working in groups in this way enables more thorough survey and is of course an important safety precaution. Equipment can be divided within the group and much less of it will be required overall. Things should be arranged in such a way that when a site is found everyone in the group will be responsible for a certain job in connection with it. Clear instructions, especially about where the groups are going, where and when they will meet, etc., are also essential. Each group should have at least one member who is experienced in cross-country travel and can locate herself or himself (and the site) with accuracy. If there are specialists available, for example, photographers, botanists or surveyors, they should be divided up between groups to distribute the expertise as widely as possible.

Here is a description of methods, personnel, equipment and time involved in a survey in Sydney Hawkesbury sandstone country to give some idea of actual field conditions.

## MANGROVE CREEK SURVEY, 1978

The aim of the survey was to locate systematically Aboriginal sites within an area of Hawkesbury sandstone country to be inundated by a reservoir. Sites had previously been reported for the general area, including a major art site. An initial survey of a third of the area located eleven sites. On the basis of this survey a decision was made to survey the remainder of the area and methods were devised to carry this out. A further aim was to record potential habitation sites; that is, rock shelters which met certain criteria as suitable for occupation but which showed no evidence of occupation. This was to enable comparison of various characteristics of the occupied and unoccupied shelters which were recorded.

Access to the survey area was by conventional and four-wheel-drive vehicles. The four-wheel-drive vehicle was also used to transfer survey teams to the starting points for each day's survey. The group

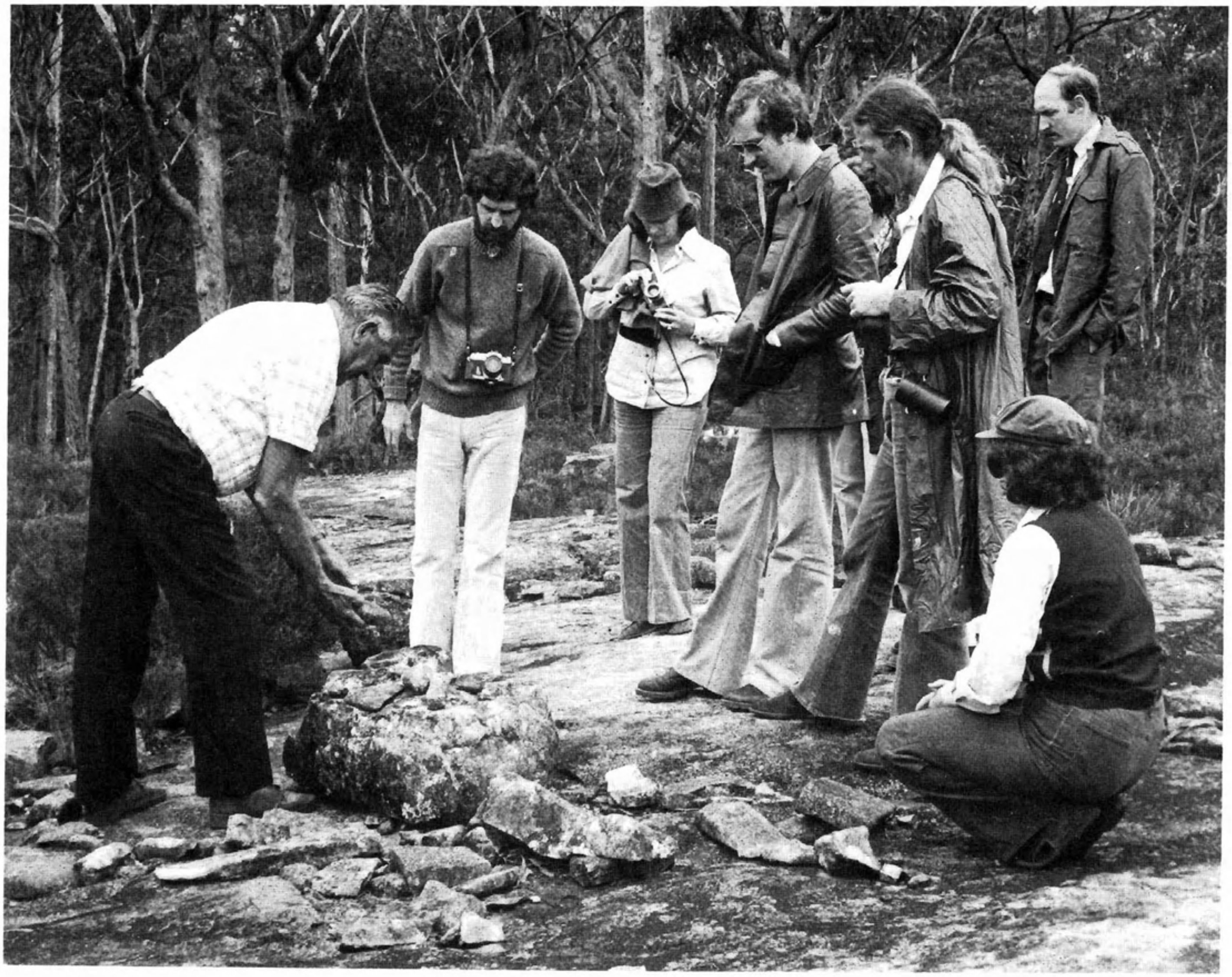


*Fig. 3*
*Site survey work often benefits from local knowledge. At this site in New England a tribal elder describes the significance of a stone arrangement.*

(about ten people) camped out at Mangrove Creek, about 40 minutes' drive from the nearest general store, garage, and telephone.

The survey was carried out between 5 and 19 January 1978 by two teams of surveyors, each with a core number of four people, led by experienced personnel. Each group had two rucksacks, one for food (lunch was taken each day) and one for maps, air photographs, clipboard, stereoscope, tape, camera, film, scale, compass, pens, pencils, plastic bags, site forms, notebook, etc. In addition, each member of the group carried a small notebook.

Each team of four people spread out at 15-metre intervals up the slope from the creek bed to the 113 metre contour. This method was found to be the most efficient way of covering the slope and looking in each rock shelter. One person in each team, positioned in the middle for ease of communication with all team members, carried the maps and air photographs and was constantly aware of the team's location. This enabled the immediate plotting of shelter coordinates. Each member of the group maintained verbal/visual contact with his/her nearest neighbour at all times. Potential habitation sites when found were recorded by two neighbouring members of the group, using agreed minimum standards of recording in prepared notebooks. The location was noted immediately. Sites, when located, were recorded fully by the whole group using standard site forms and additional photography and sketches. Artefacts were noted and left undisturbed.

The survey took 124 person-days to systematically cover 680 hectares of valley sides, dry sclerophyll woodland and forest. In all, 29 sites were located, of which 21 will be destroyed by inundation; 12 had evidence of occupation, 7 contained art, and 10 contained both occupation deposit and art. A total of 70 potential habitation sites was located. The survey located no open sites. It was considered that this was a result of poor visibility; ground cover was heavy and flat open areas on valley floors had considerable recent alluvial build up.

Following the survey recommendations

were made to the Public Works Department that a major salvage programme to excavate occupation sites and to record art sites was required before inundation. The salvage programme has revealed occupation of the area from about 11 000 BP*, and has provided much valuable information about the cultural history of the area. Many of the 'potential habitation sites' were tested, revealing archaeological deposit in a considerable percentage. (This section is a summary of Furey (1978), and Attenbrow (in press).)

## FOLLOW-UP AND RESULTS

As much as possible of the data collection process should actually be written up in the field; it is dangerous to rely on memory to describe a site. However, there will always be follow-up work translating rough data into a usable form and assembling it to meet the aims of the survey. This may range from a simple preparation of site cards to a full recording of art sites. In any case, a clear statement of the methods used should always be prepared; this is most useful when others are assessing and using the data.

## CONCLUSION

I have tried in this chapter to outline some simple guidelines for interested people who want to do basic Aboriginal site survey work. Such a guide can do no more than suggest ways of beginning such work and point to resources for gaining further skill and information. I have deliberately avoided being over-technical or too specific. Interested readers will, I hope, be able to use this chapter as a starting point; it is not intended as a detailed guide. Expertise in site survey is increasing in Australia; the theory and method of site survey are rapidly becoming more sophisticated. There is, however, still an important place for the interested amateur who can contribute greatly in this field.

*Note:* Chapter submitted in 1980.

* For an explanation of the term BP see Chapter 14, pp. 145.

## APPENDIX

### List of State and Commonwealth authorities

*Queensland*

Archaeology Branch
Department of Aboriginal and Islander Advancement
169 Mary Street
Brisbane
(GPO Box 2210, Brisbane)

*New South Wales*

National Parks and Wildlife Service
189–193 Kent Street
Sydney 2000
(GPO Box 2626, Sydney, NSW 2001)

*Victoria*

Victoria Archaeological Survey
29–31 Victoria Avenue
Albert Park, Vic. 3206

*Tasmania*

National Parks and Wildlife Service
Magnet Court
Sandy Bay
Tas. 7005

*Northern Territory*

Museums & Art Galleries of the Northern Territory,
Darwin, NT 5794

*and*

Aboriginal Sacred Sites Protection Authority
PO Box 1890
Darwin, NT 5794

*South Australia*

Aboriginal Heritage Section
Department of Environment and Planning
55 Grenfell Street
Adelaide, SA 5000
(GPO Box 667, Adelaide, SA 5001)

*Western Australia*

The Registrar of Sites
Western Australian Museum
Francis Street
Perth, WA 6000

*Australia*

The Australian Institute of Aboriginal Studies
Acton House
Kendall Street
Acton, ACT 2601
(PO Box 553, Canberra City, ACT 2601)

*and*

The Australian Heritage Commission
Casey House
Rhodes Place
Yarralumla, ACT 2601
(PO Box 1567, Canberra City, ACT 2601)

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# Chapter 2

# Contacting Aboriginal communities

HOWARD CREAMER
*National Parks and Wildlife Service, New South Wales*

The decade of the 1970s brought Aborigines and archaeologists closer to agreement than at any other time in their often stormy relationship, frequently marred by suspicion and insensitivity. Sometimes the momentum of this rapprochement either dwindled or was perhaps never established. Sites were excavated as university teaching exercises or individual research projects, and areas of land were surveyed before development, without ever involving the Aboriginal people who in many cases were living in nearby towns and reserves. Yet the work involved a search for clues as to the origins, prehistory and cultural heritage of their ancestors, information which could prove vital to the survival of the Aborigines as a distinct group within Australian society.

## A COMMUNICATION PROBLEM

Archaeologists have still to accept fully their responsibilities towards the Aboriginal community, despite a few tentative, encouraging steps by some members of the profession. A look at the contents of this book reveals tools and techniques as arcane as those for any research, but to be genuinely successful prehistorians in Australia today need to add another skill: the ability to communicate effectively with Aborigines. This is not a novel idea and the need to increase communication between archaeologists and Aboriginal people was eloquently expressed by many attending a 1975 Australia and New Zealand Association for the Advancement of Science (ANZAAS) symposium on this matter. Writing after the conference had ended, David Moore summarised part of the problem as follows:

> There is no doubt that many archaeologists frequently thank their lucky stars that, unlike their fellow workers in other fields, they do not have to deal with living people; they can happily dig away and pose their theoretical problems, without worrying about social or ethnic difficulties. Obviously this simplistic situation is now at an end. (Moore, 1975:9)

But communication is not easy, and even though the need has been recognised for some time most Aborigines and archaeologists still have a long way to go before they can be called the best of friends! As in most situations the problem is on both sides. However, archaeologists hold most of the cards and their strength implies obligations as well as rights. The responsibility for involving Aborigines in archaeology is very clear and the philosophical, moral and legal arguments in favour are overwhelming.

As well, archaeology stands to gain much from a productive dialogue with Aboriginal people and it seems that self-interest alone would have promoted greater communication than has been the case until now. But so often the challenge remains unanswered, the issue side-stepped and the Aboriginal community ignored. The few examples of cooperation between prehistorians and Aborigines stand as pointers to the way ahead. But for the majority that path is strewn with pitfalls. To plot a course through these pitfalls we have to understand why contact with Aboriginal communities is seen as a problem by many fieldworkers.

## DIFFICULTIES: REAL OR IMAGINED?

The major difficulty for most researchers is in making initial contact with Aboriginal people. Aboriginal communities often have a strong sense of separateness, isolation and suspicion of outsiders, which most other people find overpowering and distressing. This is quite natural, but it should not become an excuse for lack of interaction. Later in the chapter we take a closer look at this problem and ways in which it can be overcome. There is often doubt about where Aborigines actually live and who best to establish contact with once they are located. Another practical consideration for many archaeologists engaged in field surveys or excavations is that contact with Aboriginal people is going to take extra time and effort, and the project needs all remaining reserves of each to finish on schedule.

Prospects for successfully involving the local Aboriginal community are often further diminished by nagging questions: What does the project stand to benefit from Aboriginal involvement?; Will they really know anything useful anyway? These reservations are understandable and real enough for many would-be fieldworkers. But like the argument which contends that living Aborigines are beyond the scope of archaeological enquiry, belonging in the territory of the social anthropologist, there is an answer to these problems, as more and more prehistorians are realising.

Research projects can benefit directly from an input by Aborigines in ways examined further below. Moreover, it is now a legal obligation under the research permit system of some states to liaise with local Aboriginal communities, where these exist. But for truly effective dialogue and a more lasting relationship between researchers and Aborigines, archaeologists must be convinced of the fundamental moral and philosophical value of increased professional interaction with the Aboriginal community. Without this the commitment is at best lukewarm and at this level cannot be successful, nor to the full advantage of both parties.

## BENEFITS TO ABORIGINAL PEOPLE

The benefits to Aboriginal people arising from a closer involvement in public and academic archaeology are quite considerable. Chief among these are a clearer understanding of their history and cultural heritage as a distinct group of Australians, and increased employment and study



*Fig. 1*
*Aboriginal people from Toomelah near Boggabilla proudly showing one of three carved trees discovered by them in 1976. Archaeology has a clear role in promoting a 'revival' of Aboriginal culture in Australia.*

opportunities within archaeology. Moreover, the evidence which prehistory and anthropology can provide lends strong support to all Aboriginal people who wish to be recognised as the present-day descendants of the first Australians and to own land in areas which were traditionally theirs in order to continue a lifestyle which is uniquely their own.

It is no exaggeration that at the core of the current debate on Aboriginal rights is the very survival of Aboriginal life in some parts of Australia. Consider, for example, the furore surrounding the film *The Last Tasmanian* and the ensuing debate on Aboriginality in Tasmania, or recent events in Queensland where Aboriginal reserves have been de-gazetted because, according to the authorities, Aborigines are the same as other Australians and therefore should not receive any special treatment. Archaeological research frequently has clear political implications in that it can provide tough ammunition to support a wide range of Aboriginal aspirations, from the right to own land to the recognition of a different cultural identity.

On a national scale, few discoveries have achieved more to bolster Aboriginal pride than the now widely accepted date of 40 000 years for Lake Mungo. As well, the continuing cooperation between several prehistorians at the Australian National University, who are working on the western New South Wales project, and Aborigines living at Balranald, Menindee and Wilcannia is an example to anyone looking for guidance in contacting Aboriginal communities. The data collected by almost any archaeological survey or excavation are grist to the Aboriginal grindstone. For example, details of a subsistence economy, patterns of settlement, discoveries of ancient cave art or the salvaging of an ancestral burial from seashore erosion, can all provide the kind of evidence and information which most Aboriginal people today are eager to learn about.

Although some Aborigines, or 'Koories' as many prefer to be known, are still suspicious of archaeologists and prefer more traditional explanations of their existence such as provided by dreamtime creation mythology, the majority now accept the role that archaeology plays in establishing the foundations of Australian prehistory. This increasing acceptance is not won easily, nor should it be taken for granted. It depends on establishing an atmosphere of trust early in the project, based on consultation and an explanation of the work and giving the people an opportunity to think things over and make relevant decisions.

## BENEFITS TO ARCHAEOLOGISTS

As work on the New South Wales National Parks and Wildlife Service Aboriginal Sites Survey has shown, Aboriginal people know more about sites and their own former way

of life than they are often given credit for. This is so even in the densely populated areas of south-eastern Australia. Much of this knowledge is direct, first-hand information of traditional or historical significance which could be included in prehistory research projects, with the consent of the Aboriginal consultants. Whether it is the location of sites that local communities can assist with, or compiling resource inventories such as that undertaken by Ronald Lampert and Frances Sanders on the Beecroft Peninsula in 1971, the outcome will benefit from a realistic effort to involve Aborigines in the research. This point is made by Lampert and Sanders in their conclusion that 'Acculturated indigenous people should certainly not be ignored as a possible source of information' (Lampert & Sanders, 1973:102).

The benefits to archaeologists from talking to Koories about their research, include information on material culture, hunting and food-gathering, and a wealth of knowledge on the natural world, such as details of local geography and ecology, or the changes brought on by the seasons. For example, spears and wicker baskets can still be made in some parts of New South Wales and 'bush tucker' is frequently eaten—mainly edible plants, grubs, fish, porcupines, emus and their eggs, and macropods. An excavation of a shell midden will therefore be considerably enhanced by contemporary information on collecting and eating shellfish, something which coastal Aboriginal people know much about. There is still in the populated regions of Australia valuable information contained in oral traditions and local knowledge on sites which, provided it is not of a secret–sacred nature, people are usually willing to share with researchers they can trust.

When archaeology is linked in this way with a study of living Aborigines or ethnographic accounts from the recent past it becomes 'ethnoarchaeology' and Australia has become a world leader in this field. Examples of this are provided by the work of Betty Meehan in Arnhem Land and Richard Gould in the Western Desert, which have shown that archaeological enquiry has much to gain from direct observations of contemporary Aboriginal life (Meehan 1977; Gould 1980). This approach naturally involves the Aboriginal people in the work and gives the research a new and exciting meaning. In other areas of Australia however, contacting Aboriginal communities does not require the same level of commitment as camping among them throughout the dry season in Arnhem Land. The contact is usually more transitory although lasting friendships can stem from even a brief visit.

Summarising so far, contacting Aboriginal communities can result in successfully broadening the scope of the

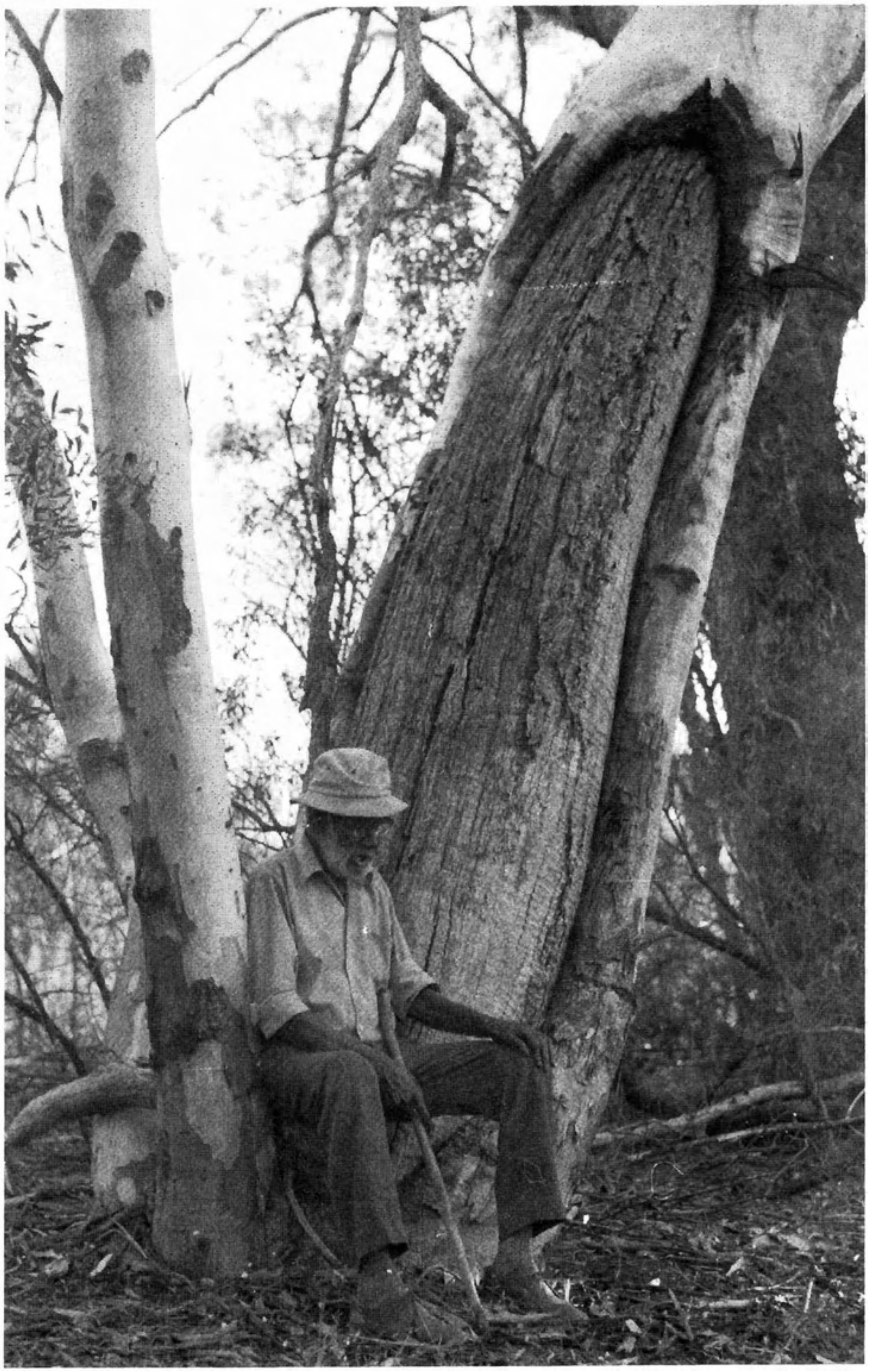


*Fig. 2*
*Robin Campbell of the Muruwari tribe at the canoe tree cut by his father in 1910 during the Culgoa River floods. This is one of a very few scarred trees in New South Wales which has a living, Aboriginal, history.*

research project to include relevant information from Aborigines and can result in creating opportunities for Aboriginal people to become more involved in archaeology. This amounts to basic courtesy, good public relations based on sound reasoning and in the long run is in the best interests of all concerned.

## INITIAL CONTACT WITH ABORIGINAL PEOPLE

No amount of advice will guarantee success in contacting Aboriginal communities because basically it is a matter for commonsense and confidence in handling new relationships. While the first is either there or is not, the other is gained from experience. Nor is it easy to write specific procedures for developing the skills needed to communicate with Koories since situations may vary, calling for a different approach and response by fieldworkers and Aborigines. However, the past experience of others can make life easier for those who follow, even if this sometimes means avoiding their mistakes. There was, for instance, one fieldworker whose methods of interviewing Aborigines are now legendary. An authoritarian figure, he would arrive in town and head straight for the police station, whereupon orders would be given to bring old so-and-so in for questioning. Out went the paddy wagon and in came the luckless informant to be interviewed, or more aptly, interrogated, in one of the cells. One wonders how many tall stories it took to secure a release from this ordeal.

The sympathetic, courteous and professional attitude of R. H. Mathews is in stark contrast to this heavy-handed approach. Although customs have changed, we can still follow his example of friendliness, humility and respect when making initial contact with Aboriginal people. This extract comes from A. P. Elkin's authoritative work on the early site recorder:

> . . . whenever he met groups of Aborigines, he observed Aboriginal courtesies of approach and the patterns of behaviour that he had learnt from childhood onwards. Thus, W. J. Enright, a lawyer of West Maitland, N.S.W., who accompanied him occasionally on visits to Aborigines on the near north coast of N.S.W. in the 1890s, told me that when RHM got near a camp, he usually lit a small fire and sat at it until invited to join the group. A small thing! but a reciprocal act of courtesy. (Elkin, 1975 : 132)

Today, many of the traditional aspects of Aboriginal culture have given way to a social structure and norms of behaviour that can be more easily understood by a researcher who approaches with sympathy and an open mind. Yet Aboriginality is as distinctive in other ways as it ever was, and the initial contact with an Aboriginal community can be a difficult time for both sides. To the researcher or field staff Aboriginal people may appear at first to be drawn together behind a cloak of secrecy, a tightly knit society that will allow no intruders. This impression is only partly correct; naturally, Aboriginal communities have had to maintain a low profile in order to survive in a brash and critical society that is only too willing to ridicule their beliefs and way of life. However, confidence and rapport usually come more freely if there are clear and compelling reasons why cooperation is desirable, as with the investigation and protection of Aboriginal sites.

Besides having to balance confidence with humility and friendliness with respect, researchers should be prepared to make a commitment on the level of Aboriginal involvement in the project. One of the first questions in response to hearing a fieldworker's plans is usually, 'What's in it for us?'. This is an understandable reaction and the response should be explained sensitively and honestly, perhaps using the general points raised in the earlier section dealing with benefits to Aboriginal people. Additional factors may be relevant, depending on the particular circumstances. If, like Jeannette Hope and her co-researchers on the River Darling–Lake Mungo project, you have sufficient funds in the grant or contract to employ Aboriginal assistants the proposed fieldwork is more likely to be greeted with enthusiasm. Such a practical proposal as this can be expected to result in a successful initial contact, greater community interest throughout the project, and lasting relationships which in the long run can only help to unite Koories and archaeologists.

## ARRIVAL AND DISCUSSION

Before an approach is made to the Aboriginal community, it is advisable if possible to telephone someone, or at least to have the name of a contact person to ask for on arrival. It is sometimes as difficult to drive onto an Aboriginal reserve unannounced and feel welcome, as it is to do the same thing to some landowners on their properties. An increasing number of Aboriginal communities now have a telephone and these numbers, and the names of people to contact, can be obtained from researchers and community workers familiar with the area. Useful contact points other than individuals or advancement associations and cooperatives are the Aboriginal Medical Service, the Aboriginal Legal Service, the Aboriginal Employment and Training Branch of the Commonwealth Employment Service, and the various departments and museums responsible for the location and protection of Aboriginal sites in each state. In New South Wales the National Parks and Wildlife Service maintains a list of Aboriginal communities and contacts which can be used by anyone working in that state.

The majority of Australia's Aboriginal people still live on designated reserves, which were set aside for a declining population between the 1880s and 1950s. They are usually some distance away from the town, reflecting the view then widely held by Europeans, that this 'out of sight, out of mind' segregation would at least keep the Aboriginal 'problem' at a distance. Today, increasing numbers of Aborigines are accepting homes built by the Housing Commission in towns, where some of them are lucky enough to have found employment. It is to both these places that archaeologists must go to contact Aboriginal people when they are planning to undertake fieldwork.

On arrival, put aside the apprehensions and relax. Although you think that the battered vehicle loaded to the roof with survey and excavation equipment looks conspicuous, your visit is going to attract greater attention if you are flustered and nervous. Remember that Aborigines are used to whites calling on them for a variety of health, welfare, educational, legal and employment reasons, and they have learnt to assess newcomers at face value, on what they say and what they can offer the Aboriginal cause. This being the case, archaeologists and site recorders have a good chance of gaining the confidence and trust of Aboriginal people because we have much to offer. If we are sincere about involving the people in researching the sites left by their ancestors and in respecting their wishes concerning those sites, then the nature of our work can provide a passport to acceptance by Aboriginal communities.

Discussions may eventuate soon after arrival at the local Aboriginal community, or it may take a while, even a return visit, before the key members of the group are present. It is important to speak to the *de facto* decision-makers in the community or

there will be no lasting agreement to which to adhere. Mostly, these people will be the contacts you have in mind before setting out, and therefore they will be among the first you meet in town or on the reserve. If you are unsure of who to involve, tell the people and ask for their assistance to locate all those who may be interested. There are often covert divisions within Aboriginal communities, as indeed elsewhere, about which any researcher venturing to establish contact should be aware. These are not only between young and old, and men and women, but are also based on tribal, local and family ties. In some cases it will be vital to clarify which group speaks for a particular area so that they can be consulted first, although this does not always rule out the other groups from becoming involved.

However, as we have seen in the previous section, any offers of involvement must be genuine and meaningful to the community. Whether the project is an excavation or a sites survey, an opportunity could be given to the younger Aboriginal people to participate as field assistants alongside staff and students and so learn from first-hand experience the skills required in prehistory fieldwork and site recording. Try to arrange for the local Aboriginal association or cooperative to visit the excavation or survey area, and explain to them what is going on. If one or two Aborigines are particularly interested in the project why not offer to take them along on the search for sites and later back to the laboratory to see the results unfolding. If you are carrying out an assessment of the impact of development on Aboriginal sites, carefully explain the land-use proposal, outlining the areas involved. In the case of salvage archaeology, where time is limited, try to establish the full cooperation of the community to locate all sacred and significant sites, as well as those archaeological sites discovered during fieldwork, prior to the commencement of operations, so that they can be protected before any damage occurs. Throughout, aim to talk in a clear and direct manner, avoiding the use of technical terms which are not widely understood. Sincerity, honesty and a sense of humour will find quick appreciation and help the discussions along, towards a workable conclusion.

*Fig. 3*
*An archaeologist working at Narran Lake in western New South Wales explaining its importance to a group of Aboriginal people from nearby Walgett. Opportunities should be created whenever possible for Aboriginal people to learn from field archaeology.*



## SPECIAL PROBLEMS

Despite careful preparation, good timing and productive discussion, there may still be problems which will take understanding and patience to resolve. Most common is the need for more time for the people to think and talk about the proposals put forward by the archaeologist. This is to be expected during these early days of cooperation between researchers and Aborigines, when few people in the community will have had previous experience of sites survey work or excavations. Delays in setting out to see the areas under discussion can also occur while food is obtained, pension payments collected, or in waiting around for others to arrive. Pensions are paid on alternate weeks and usually involve a visit to town, often making contact and consultation difficult. So be prepared for these minor setbacks; be patient, and allow more time than at first seemed necessary.

Two types of sites in particular present special problems for archaeologists intending to work closely with Aboriginal people. These are burials and 'sacred' sites, including those which it is said women may not visit. The occurrence of burial sites is widespread in close association with coastal dunes, shell middens, inland sand hills and recent Aboriginal settlements. Factors such as the importance of burials to Aborigines, their value to archaeological investigation and the constant threat they face from disturbance, ensure that archaeologists and site recorders are faced with this type of site early in their careers.

The most common situations in which burial sites are discovered will seldom cause problems for the relationship between researchers and Aboriginal people and may even strengthen this bond. In the context of a 'salvage' operation, the skeletal material is probably in danger from vandalism, souvenir hunters, weathering, or development such as sand mining, quarrying, road making or housing construction. It is then possible to rescue the burials by isolating the threat and providing alternative development plans, or stabilising the site, or reburial elsewhere, depending upon Aboriginal wishes and the particular situation. Likewise, a sites survey, conducted with the full involvement of local Aborigines, will usually identify burial sites before they are disturbed. In saving the sites and avoiding a distressful confrontation, the archaeologist emerges as a friend to the Aboriginal people, and a peacemaker to the land-use authorities.

For nearly a decade archaeologists have stressed that skeletal material is a small, although scientifically valuable, part of their total research. Some of them have never excavated a burial and have no intention of ever doing so. These days sites are very seldom investigated primarily to discover burials, but human bones may occur within a more extensive site and these can be carefully collected for reburial when the work has finished. Many younger Aboriginal people accept that research into prehistory involves the study of properly excavated and dated skeletal material. This is certainly the view of those working as site recorders or with some knowledge of archaeology. Most people would acknowledge that the careful examination of the burial at Lake Mungo and its skilful reconstruction, dating and interpretation, has provided a major contribution to the immense power of this site to excite the imagination of archaeologists, Aboriginal people and everyone with an interest in the prehistory of Australia.

Despite these potentially positive and productive associations with burial sites there can still be considerable problems. The harrowing experiences of the past and the mistakes of previous researchers are often symbolically concentrated in the memories of Aboriginal people, on the remains of their ancestors. Never again, they vow, will the 'gubbas' be able to vandalise these sacred grounds, looting their contents, and openly exhibiting the bones in museums and laboratories on public display. It is still the case, therefore, in situations where agreement is sought from the local Aboriginal community for the excavation of burials which are not in danger, that the answer may be 'no'. This can be avoided if there is a lengthy association between the archaeologists and the Aborigines of trust, sincerity and involvement in the research, and even then, the answer may still be 'no'.

There is insufficient space in this chapter to discuss the problems of researching 'sacred' sites in detail, except for a few basic observations. If a site or area is out of bounds because it is recognised by an Aboriginal person as being traditionally sacred, then no one, male or female, white or uninitiated black, should venture there without the full authority of the relevant Aboriginal elders, and then if possible only in company with them. This is basic to an understanding of traditional Aboriginal society, which frequently exacted the penalty of death for unlawful visits or sightings of sacred places. In this case the archaeologist who in good faith seeks local Aboriginal approval for a research project will just have to omit the sacred places from the survey area. However, where an environmental impact survey is being undertaken it should be stressed that sacred sites cannot be guaranteed protection without basic location information being made available. This may mean that someone chosen by the elders will have to visit the site and outline the general area on the survey map, information which can and should be kept as confidential as possible.

There is also an increasing tendency throughout Australia to ascribe the quality of 'sacred' to sites about which there is no recent tradition of them being so, as has happened in places as far apart as the Pilbara and Portland (Victoria). As with their traditional counterparts, the sacredness of these sites is rarely open to negotiation with the Aboriginal consultants. This is something which anthropologists and the public have to some extent brought about by their interest in, and emphasis on, the importance of the 'sacred' life in Aboriginal culture. Aborigines are then left with the impression that Europeans will only take notice of something if it is 'sacred'. It is also a means by which certain places and sites are given a heightened value in these inflationary times, which have seen such a severe erosion of Aboriginal lands and dramatic destruction of their sites. Those few remaining are of relatively far greater importance to the people and consequently become 'sacred' in a contemporary sense. Given the present dynamics of culture change, there is very little which can be achieved by trying to dissuade those concerned from continuing to use the 'sacred' classification although the potential problems thereby created can, and should, be clearly stated to the Aboriginal community.

'Sacred' sites, when put off-limits to researchers, may be at risk in areas undergoing destructive development, with the consequent loss of a valuable national resource, and their potential to enlighten the public on the attributes of Aboriginal society will remain unrealised for as long as they are a secret. This restriction is also a problem when a researcher, often a woman, is prevented from continuing investigations because of the prohibition on women visiting a particular area. The best that can be done, if an alternative research project cannot be found, is to defer the work until such time that the proposal finds a more general level of acceptance in the Aboriginal

community. In some cases this may not be until the community has members who themselves have degrees in prehistory and who can appreciate the merits of the research, as well as being effectively involved in decision-making in the community. There is, of course, a strong case to be made for protecting, with the strictest secrecy, sites which are in a traditional sense 'sacred', or are considered by all to be so today. It is just that sometimes it is apparent that not everyone is sure what is 'sacred' as opposed to 'significant', and the problems that this confusion causes for anyone attempting to assign relative priorities for protection may result in some sites being destroyed.

## FEEDBACK AND FOLLOW-UP

Contact with Aboriginal people should not cease once the fieldwork is over. This has the appearance of being expedient and mercenary, a 'marriage of convenience' while the work is under way. It also misses a great opportunity for continuing contact, bringing benefits to both archaeologists and Koories if they can maintain their relationship. This final section discusses some possibilities for achieving this and these are referred to as the 'soft' and 'hard' options for feedback and follow-up. First the soft options, which amount to little more than basic courtesies and are carried out by most researchers working with Aboriginal people.

Aboriginal people have a word for researchers who only show up when they are on initial fieldwork; they are called 'oncers' for only coming once. Sometimes it is inevitable that there will only be one chance to visit the community and the best that everyone can hope for is that the contact will be positive and rewarding for both sides. But there is no substitute for a return visit and this opportunity can be used to renew friendships within the community and bring people up to date with the progress of the research. A good way to do this is to prepare a slide talk and invite the people to a meeting. Another idea is to write a report specifically for local Aboriginal use, as this is often the most effective and appreciated form of feedback that fieldworkers can provide. The report should contain a variety of photographs, including photographs of the main consultants. In addition, researchers should be prepared to publish relevant, non-academic, feedback material in magazine or booklet format to reach a wider Aboriginal audience. This information will help Aboriginal communities to justify to others the importance of their sites and their claims to land. It will strengthen their local identity and in some cases assist their actual survival as a distinct group of people. The final suggestion in the soft option category is to place Aboriginal consultants on any appropriate mailing lists for newsletters which may be of interest to them, and to write to them yourself as often as possible.

Feedback and follow-up of this nature is elementary, although absolutely basic to successful on-going contact. However, two of the hard options must be faced immediately the fieldwork is over. First, any payment for interviews, field assistance or other cooperation which has been negotiated or taken for granted should be arranged promptly. Aboriginal people, more than salaried professionals, rely on cash-in-hand for their day-to-day needs. Advice on the different rates is available from the relevant departments of public archaeology in each state or from the Australian Institute of Aboriginal Studies. Factors such as the time involved in site investigation, the value of the information to the project, travel time, and urgency of the research, will determine the appropriate rate for payment of consultants' fees.

Even more welcome than a fair payment for assisting the research as a consultant or fieldworker is a commitment on the protection of the sites. But how far can an individual go in making promises regarding sites which have recently been investigated? This again depends on the circumstances, particularly the level of protection requested, and researchers have it in their power to achieve much in this regard. If the information is to be kept secret, or alternatively passed on to someone else in authority, with a supporting statement, the archaeologist is in a position to do this. Likewise, basic protection and conservation measures for sites, such as fencing, reduction in fire hazard or the removal of graffiti, can be organised by researchers through their universities, museums or relevant government departments.

A problem will arise, however, during a sites survey where a potentially valuable economic development threatens the safety of certain sites. As the employees of the government or a conservation organisation, archaeologists cannot give a firm commitment to the preservation of sites since they will not make the final decision, as recent events at Noonkanbah clearly show. All that we can hope to achieve is to present an accurate description of the sites and a fair assessment of their overall value, scientifically and to the Aboriginal people. Where a land-use conflict appears inevitable, recommendations which will avoid the destruction of sites should be strongly urged. These can include 'zoning' the development to leave undisturbed areas around the sites, re-routing or diverting a linear development such as a road or pipeline, and salvaging sites of useful information or relocation to safer places as with an isolated skeleton being re-buried at an Aboriginal cemetery.

Finally, the continuing contact between archaeologists and Aborigines will rely on such tangible rewards as employment and study opportunities within Australian prehistory. Many of the problems which both sides face in their efforts to see eye to eye on issues of mutual concern arise from there being too few Aboriginal people employed as site recorders, technical assistants, and administrators and too few qualified as archaeologists and anthropologists. There are signs that this is changing. For example, the New South Wales National Parks and Wildlife Service currently employs about 20 Aboriginal people whose work involves site management, and the University of New England offers external courses in prehistory in which several Aboriginal people are enrolled. Closer involvement of Aboriginal people in making decisions that affect their sites and land is also possible through membership of government advisory committees, participation in departmental seminars and through the effective representation of Aboriginal wishes by close associates such as friends in archaeology and related fields of research.

The potential ramifications of the initial decision to contact Aboriginal communities are clearly considerable. In research terms, the satisfaction that the project has gained from a contemporary Aboriginal perspective and not overlooked this important source, makes the effort worthwhile. Then there is the reward of lasting friendships with Aboriginal people and, with them, the reminder that Australian archaeology is no longer the detached pursuit of theoretical models it has become in some places, but that it relates to living people who to some degree depend on it for the foundations of their cultural inheritance. Archaeologists owe it to Aborigines to create an atmosphere of trust, in which can flourish an exchange of ideas and aspirations and which can result in a wide range of opportunities for involvement in pre-

history, all of which begins with the simple act of good faith inherent in contacting Aboriginal communities.

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*Note:* Chapter submitted in 1980.

# Chapter 3

# Archaeology and legislation in Australia

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Archaeologists have rights of access to archaeological materials not generally shared by other members of the public; these rights, however, are balanced by a series of obligations, both moral and legal. The serious student of the discipline will be well aware of the former—which include *inter alia* the necessity for respect for the materials themselves, the rights of others such as landholders and any likely descendants of the prehistoric communities with which he is concerned, the obligation to share his newly won knowledge with others through publication of the results of his research—but the more formal, legislated, obligations might be more obscure. It is contingent upon researchers, however, to make themselves thoroughly aware of their obligations under the law.

One difficulty that the archaeologist faces in Australia is the multiplicity of state laws relating to archaeological sites and collections. It is an unfortunate facet of the federal/state division of authority in this country that has led to a proliferation of legislation, each state having its own—and in some, more than one—set of statutes applying to 'archaeological relics'. All contain inadequacies from the point of view of protecting archaeological sites and excavated materials. There is little evidence of consultation amongst the various state legislators in the drawing up of the various legislations. Most fail to deal with materials obtained from beyond state borders so that, for example, while an artefact obtained near Broken Hill may not lawfully be sold in Melbourne it may be sold in Adelaide. In general, the lack of uniformity in the legislation is likely to provide difficulty for the archaeologist attempting to work in more than one state.

This is an inopportune time to have to attempt an overview of the legislation in Australia. In some states legislation only recently has been supplemented, revised, replaced or complemented and there has been little opportunity to observe the effects of these changes; in others, substantial changes are under way or are envisaged for the near future. Thus, while it might be possible to provide an adequate summary, it will soon be out of date, and it is not possible to relate how the newer legislation is administered.

Nor is it possible to cover the area of implementation of the law in anything like the detail warranted: this subject would require another paper on its own. In some areas of the law, one might observe significant differences in emphasis between the concerns of the original legislators and the current administrators and the archaeologist might need to consider this aspect of the interpretation of the relevant legislation. In one state, for example, a minister has made an unusual interpretation of one section of the act he is supposed to administer in order to negate the more explicit provisions of another section, thus using the act against its original purpose—protection of sites or at least the mitigation of damage in the face of developmental processes.

In the short space available, implementation of the legislation cannot be considered in detail. The interested reader can find some discussion relating to the situation pertaining in Tasmania, Western Australia, Victoria, Queensland and South Australia in a paper by Neate (1978a) and another by Trigger (1980) relating to Queensland.

This chapter attempts to provide an outline guide for archaeologists and members of the public to the various sets of legislation in force in each of the Australian states. It does this by seeking answers in that legislation to a series of questions covering major areas of concern:

(a) details of date of legislation and its administration;
(b) responsibilities for research and recording;
(c) site protection and management;
(d) artefact protection and management;
(e) permission for survey and excavation;
(f) salvage of threatened sites;
(g) reports of research.

The legislation in each state is approached in turn and for each the answers obtained are summarised in a table which provides the basis of the discussion.

Some difficulties and limitations of this heuristic procedure must be noted. By forcing the various acts through the structure selected for the table an inaccurate impression of uniformity may be given; it is necessary to emphasise that the legislations considered here are not only dissimilar in many areas of detail but also have been written from various philosophical stances. There are some exceptions among the later acts which have drawn—occasionally uncritically—from preceding examples. Again, in order to simplify the presentation, some universal terminology has been applied. For example, the term 'reserved land' has been selected to refer to areas of land variously resumed and/or set aside with the intention of protecting 'relics'. The terms 'protected area' and 'prohibited area' are used—sometimes uncomfortably—to refer, in the first case, to an area of land where certain restrictions apply to the type of activity that might be carried out and, in the second case, to an area to which even *access* is restricted to those with an appropriate permit.

The section on the restriction/prohibition of export of artefacts is of less consequence than might have been expected. Few states cover this area. It is possible that the reasons are that they find, on the one hand, that restrictions upon 'export' to another state are constrained by the 'free trade' provisions of the federal constitution and, on the other, that export from Australia is covered by the federal Customs Act.

Such a discussion as this cannot be a substitute for a detailed reading of the legislation itself. The names of the various

acts, the places from which copies can be obtained and the names and addresses of the authorities currently responsible for implementing the legislation are given in an appendix.

The legislation applying in each state at the time is reproduced in full in the symposium volume edited by Edwards (1975); unfortunately, much of this is now out of date. An earlier discussion of the nature of Aboriginal antiquities and their preservation, including the provision of legislation, was provided in the volume edited by McCarthy (1970); in this the papers by Edwards, Killoran, Carn and Piesse remain of some interest. It should be noted also that most of the legislation reviewed here applies to historical antiquities and prehistoric materials relating to other than aboriginal Australia. Some recent reviews and discussions appear in the Australian and New Zealand Association for the Advancement of Science (ANZAAS) Symposium volume edited by McKinlay & Jones (1979); Neate (1978b) has provided an overview covering aspects of antiquities legislation in an unpublished paper; the world-wide review by McKinlay (1973) is still of interest, as is the coverage of the American situation by McGimsey in 1972. The recently published discussion by Miller (1980) and the subsequent comment in *Current anthropology* will also be instructive, as will any comparison with the US situation (King, Hickman & Berg, 1977).

Other legislation besides those acts reviewed here might affect archaeological activities but it has been impractical to attempt to be comprehensive in this regard. One example may suffice. The New South Wales *Heritage Act 1977* is 'An Act to conserve the environmental heritage of the state'. While it treats mainly the built environment it defines the 'environmental heritage' as:

> those buildings, works, relics or places of historic, scientific, cultural, social, archaeological, architectural, natural or aesthetic significance for the State. [Section 4]

and, clearly, impinges directly upon matters of concern to the archaeological research worker. On the other hand, a 'relic' means:

> any deposit, object or material evidence relating to the settlement prior to 1st January, 1900 . . . not being Aboriginal settlement. [Section 4]

The act currently is interpreted generally to exclude items of the Aboriginal heritage; no doubt, however, those researchers working in the area of historical archaeology ought to consider its provisions dealing with 'conservation orders', for example, since activities such as excavation are controlled in areas covered by such orders (Section 57).

## THE VARIOUS STATE LEGISLATIONS

### Western Australia

The *Aboriginal Heritage Act of 1972* is the first piece of legislation to be reviewed since it is probably the most complete legislation from among the Australian states. More than this, it takes a unique stance; it assumes ownership by the state of all known and as yet unrecorded Aboriginal and archaeological sites and artefactural material. From this assumption, all other clauses and regulations flow more positively than in any of the other states' legislation. Clearly, also, from the point of view of the wider community, this stance better allows protection and management of sites and other cultural materials; it might be anticipated, however, that it will at some time come under attack from development interests, on the one hand, which will find it too protective and Aboriginal groups, on the other, which will wish to manage their own concerns. At present, it is the most comprehensive legislation and one against which other acts might be evaluated. In mid-1980, in the wake of the Noonkanbah dispute, the Aboriginal Heritage Act was under attack and said to be likely to be revised to restrict the powers of the Western Australian Museum and make it easier for 'development' to proceed (for example, see Warren, 1980). Subsequently, the act was substantially amended (September 1980) with the aim of severely restricting the powers of the Trustees of the Museum and concentrating them in the hands of the Minister. Thirteen sections were changed, the Minister's authority being made explicit in paragraphs such as this:

> The Minister may—
> (a) after consultation with the body concerned, give to the Trustees, or to the Committee;
> (b) give to the Director or to the Registrar, directions of a general or specific character as to the exercise of any function under this Act or the doing of any thing for the purposes of this Act and that body or person shall give effect to any such direction. [Section 11(2)]

The amendments were reported to have been the subject of scathing criticism by the Western Australian Anthropological Society (Anon. 1980a) and the Aboriginal Legal Service (Anon. 1980b). A pamphlet later issued by the Government of Western Australia made it clear that it was not going to accept the advice of the Trustees of the Museum when that advice stood in the way of development projects such as the one it was promoting at Noonkanbah:

> June 8, 1979. Against this background, the Government directed the Minister for Cultural Affairs to direct the Museum Trustees to release the site for drilling. [Anon. 1980c: 13]

The amendments provide the Minister with a more secure basis for directing the Trustees in future.

In the following discussion, additions made by the 1980 amendment act have been emphasised and those excised placed in square brackets. With regard to places (Section 5),

> The Act applies to—
> (a) any place *of importance or significance* where persons of Aboriginal descent have, or appear to have, left any object, natural or artificial, used for, or made or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people, past or present;
> (b) [any place, including] any sacred, ritual or ceremonial site, which is of importance [or of] *and* special significance to persons of Aboriginal descent;
> (c) any place which, in the opinion of the Trustees, is or was associated with the Aboriginal people and which [may be] *is* of historical, anthropological, archaeological or ethnographical interest *and should be preserved because of its importance and significance to the cultural heritage of the State*;
> (d) any place where objects to which this Act applies are *traditionally* stored, or to which, under the provisions of this Act, such objects have been taken or removed[;].
>
> [and which has not been excluded from the provisions of this Act by agreement with the Trustees in accordance with subsection (6) of Section 18.].

(Section 18(6) allows exclusion of provisions of the act of a site or part of a site required for other purposes.)

The next section of the act deals with portable artefacts and applies to:

> (i) . . . all objects, whether natural or artificial and irrespective of where found or situated in the State, which are or have been of sacred, ritual or ceremonial significance to persons of Aboriginal descent, or which are or were used for, or made or adapted for use for, any purpose connected with the

traditional cultural life of the Aboriginal people past or present;

including facsimiles but excepting those made for sale (Section 6).

The act requires that '. . . all places in Western Australia that are of traditional or current sacred, ritual or ceremonial significance to persons of Aboriginal descent . . .' be recorded and evaluated (Section 10 (1) ) and that all cultural material be similarly considered (Section 10 (2) ).

The Minister is to be advised and assisted by the Trustees of the Western Australian Museum, the institution selected to implement the act (Section 10 (3) ) and the Trustees, in turn, are to be advised by the Aboriginal Cultural Material Committee (ACMC) established for that purpose (Section 28). Its members are to consist of (a) those appointed by the Minister and (b) *ex-officio* members. Of the former,

> . . . one shall be a person recognized as having specialised experience in the field of anthropology as related to the Aboriginal inhabitants of Australia . . .

appointed after consultation with members of a tertiary institution in the state (Section 28 (3) ). The *ex-officio* members shall be the Director of the Museum, the person immediately responsible to a minister for the administration of Aboriginal affairs, and the Surveyor-General in the Department of Lands and Surveys (Section 29).

The Registrar of Aboriginal Sites at the Museum is required to maintain (Section 38) a register of protected areas, Aboriginal cultural material (if classified) and other places and objects to which the act applies including those outside Western Australia (because the clauses involving objects have not been invoked, no register of objects currently is maintained).

The functions of the ACMC are, *inter alia*,

- (a) to evaluate on behalf of the community the importance of places and objects alleged to be associated with Aboriginal persons;
- (b) where appropriate, to record and preserve the traditional Aboriginal lore related to such places and objects;
- [(c) to preserve, acquire, and manage on behalf of the Trustees, places and objects which in their opinion are, or have been, of special significance to persons of Aborginal descent;]
- [(d) to carry out such of the activities or functions of the Museum, or of the Trustees, as the Trustees may with consent in writing of the Minister delegate to the Committee;]
- *(c) to recommend to the Trustees places and objects which, in the opinion of the Committee, are, or have been, of great significance to persons of Aboriginal descent and should be preserved, acquired and managed by the Trustees; . . .*

In evaluating the importance of places and objects the Committee would take into account

- (a) any existing use or significance attributed under relevant Aboriginal custom;
- (b) any former or reputed use or significance which may be attributed upon the basis of tradition, historical association, or Aboriginal sentiment;
- (c) any potential anthropological, archaeological or ethnographical interest; and
- (d) aesthetic values.

Sacred beliefs and ritual or ceremonial are to be regarded as primary considerations in the process of evaluation (Section 39).

The Trustees of the Museum are responsible for care and protection of places and objects defined by the act (Section 12). Any person with knowledge of the existence of an archaeological site or one of Aboriginal significance or an item of cultural material is required to report its existence to the Trustees, or to the police, unless he believes its existence is already known (Section 15).

The Trustees may appoint honorary wardens, providing them with identification, to act in specific areas or throughout the state (Section 50). Wardens and Museum staff may enter premises (other than those used exclusively as private dwellings) to examine any Aboriginal site or object and to request relevant information (Sections 51 to 55).

With regard to archaeological investigation the researcher should bear in mind that

> (1) *Subject to Section 18,* the right to excavate or to remove any thing from an Aboriginal site is reserved to the Trustees,
>
> (2) the Trustees may authorize the entry upon and excavation of an Aboriginal site and the examination or removal of any thing on or under the site in such manner and subject to such conditions as they may direct. [Section 16]

Further, it is an offence to excavate, destroy, damage, conceal or in any way alter a site, or to alter, damage, remove, destroy, conceal, assume possession of an object on or under a site, or to deal with it 'in a manner not sanctioned by relevant Aboriginal custom', without the consent of the Trustees under Section 16 *or the consent of the Minister under Section 18* (Section 17).

'Protected areas' under the act may be declared by the Governor, by order in Council, about any site, whether on publicly or privately held land (Section 19) but now, with the changes in the act, only after the Minister has sought objections and had them evaluated by the Trustees and only upon the recommendation of the Minister himself (Subsection 1 to 3). Protected areas may be revoked or varied by the Governor, by order in Council, now, more directly upon the recommendation of the Minister, rather than by representations of the Trustees (Section 21) and without consultation with them (Section 25). The area may be marked by notices and fenced and it is an offence to interfere with such notices or fences (Section 23). In order to protect sites within them, regulations may be made prohibiting or restricting entry onto protected areas, the use of vehicles, explosions etc. within them, damage to vegetation, the surface or the subsoil and the entry of livestock and it is an offence to contravene any provision of such a regulation (Section 26).

For the purpose of protecting Aboriginal objects, the Governor, by order in Council, may declare an object or class of objects to be classified as 'Aboriginal cultural material' on the advice of the Trustees that it is/they are:

> (a) of sacred, ritual or ceremonial importance;
>
> (b) of anthropological, archaelogical, ethnographical or other special national or local interest; or
>
> (c) of outstanding aesthetic value, . . . [Section 40]

It is then necessary for anyone with such an object to advise the Trustees, giving a description of the object and an account of the manner in which it came into his possession or control; he must produce it for inspection and recording by them (Section 41) and, possibly, relinquish it into their possession (Section 42). Anyone with an object classified as 'Aboriginal cultural material' may not (a) sell, exchange or otherwise dispose of it; (b) allow it out of the state; or (c) wilfully damage, destroy or conceal it, unless he is authorised to do so by the Trustees or he is an Aborigine 'acting in a manner sanctioned by relevant Aboriginal custom . . .' (Section 43). There are provisions for purchase (Section 43 to 46) and compulsory acquisition by the

Museum (Section 47), restricting the exhibition of sacred or ritual objects (Section 48) and prohibiting or restricting publication of such objects (Section 49).

Section 12 of the 1980 amendment removed a potentially significant (albeit one seldom, if ever, used) penal provision of the original act which provided that, where a person was convicted of an offence committed

> (i) knowingly;
> (ii) for the purpose of gain; and
> (iii) with intent to defeat the purposes of the Act, the court . . . may order the suspension or forfeiture of any right, title or interest held by that person in or affecting that land or anything on or under that land or any mining tenement or mining privilege . . . notwithstanding the provision of any other Act or law in the State. [Section 58]

*Summary*

The Western Australian act remains one of the more comprehensive pieces of legislation relating to archaeological resources in Australia, despite the recent amendments which could be seen to have compromised its potential to offer proper protection to sites by removing much of its power from an expert body to the hands of a minister of the Crown, were that minister's government concerned to act toward the negation of the intent of the act in particular cases, or even in general.

The archaeologist's responsibilities when conducting research in the state are clearly defined in several sections, among which Section 16 is central, reserving as it does the right to excavate to the Trustees of the Museum. He should also consult with the Museum regarding the location of protected areas into which entry might be restricted. The Department of Aboriginal Sites at the Museum maintains a register of sites which could be of considerable value to anyone initiating research with a survey of an area. The Trustees' permission is required before removing 'classified objects' from the state.

Little published material relating to the legislation and its implementation appears to be available. There is a pamphlet provided by the Museum entitled *Western Australians and the Aboriginal Heritage Act* but this is not very informative with regard to the archaeologist's responsibilities. The contribution by a former Registrar of Aboriginal Sites at the Museum to the collection edited by Edwards is now partially out of date (Dix, 1975). There is available from the Museum a three-page summary of the main provisions of the legislation entitled *Extracts from Aboriginal Heritage Act 1972–1980.*

### Northern Territory

The picture in the Northern Territory is complicated by the presence of two sets of legislation relating to the management of sites, both of which might involve archaeological material. The first is an ordinance of the Commonwealth Government dating from 1957, the second an act promulgated by the new state-like government of the Territory in 1979.

*Native and Historical Objects and Areas Preservation Act 1955–1960*

This ordinance initially was made as the *Native and Historical Objects Preservation Ordinance* of 1955 by the Administrator of the Northern Territory, slightly amended in 1960 and again in 1961. By comparison with the Western Australian act, the Northern Territory legislation is simple, basic and inadequate in many areas. Its objectives are to preserve certain objects and areas of land; it sets out to do this by proscribing the removal from the Territory of a 'prescribed object' which is defined in Section 3 as:

> (a) an object relating to the aboriginal natives of Australia which is of ethnological or anthropological interest or value;
> (b) an object relating to the Territory which is of archaeological or historical interest or value;
> (ba) an article manufactured by an Australian aboriginal native with native tools and according to native methods; and
> (c) such other objects of ethnological, anthropological, archaeological or historical interest or value as are prescribed, . . .

but does not include a range of wooden and metal artefacts (Section 3 of 1955–1960 ordinance; see also Section 3 of 1957 Regulations). The Administrator may purchase or otherwise acquire an object on behalf of the Commonwealth, make regulations to prevent the removal from the Territory under certain conditions of a prescribed object (Section 7). The regulations require that a person 'shall not knowingly conceal, remove, destroy, deface or otherwise damage a prescribed object' (Section 8) and that knowledge of the location of a prescribed object shall be provided to authorities when requested (Section 9). Under certain conditions, authorities may seize a prescribed object (Section 12). Contravention or failure to comply with the regulations constitutes an offence (Section 10) and an offender, in addition to any other penalty, may forfeit possession of a prescribed object to the Crown (Section 11).

Land reserved under the *Crown Lands Ordinance 1931–1959* may be declared a prescribed or prohibited area. No one may enter such an area unless he has written permission to do so (Section 9G) and an appointed

> Ranger may require any person in a prescribed area whom he has just cause to suspect of having committed, or being about to commit, an offence against this Ordinance, to give his full name and address . . . [Section 9C]

and, ultimately, a Ranger may require that person to leave the prescribed area (Section 9F). Further,

> A person shall not wilfully or negligently deface, damage, uncover, expose, excavate or otherwise interfere with—
> (a) a cave or other place in which ancient remains, human or otherwise, are situated; or
> (b) a place which is or has been at any time used by Australian aboriginal natives as a ceremonial, burial or initiation ground,
>
> except with the written permission of the Administrator. [Section 9H]

Clearly, the effectiveness of this legislation is constrained by a number of factors, important among which is the fact that much of it applies to a limited number of 'prescribed areas', which can be declared only on Reserves or Crown Land, rather than to all archaeological sites and sites of contemporary significance. On the other hand, Section 9H is much more generally stated and has implications for all sites with archaeological manifestations; indeed, it would appear that this is one of the more powerful provisions and requires careful consideration by archaeologists as well as developers and other members of the general public.

It may well be that the range of this provision has led to the de-emphasis of other aspects of the legislation in its implementation since, for example, under Section 9A, sites 'must be surveyed, exactly described and gazetted for public information' and this provision has resulted in considerable delays in their definition thus severely circumscribing the practicability of the legislation (Milliken, 1975: 20). Whatever the reason, 17 years after the

commencement of the initial legislation, a very limited number of sites had been formally prescribed (Jack-Hinton, 1975: 24). At the same conference, in 1972, Jack-Hinton described the main limitations of the legislation thus:

> . . . there is no provision for the absolute seizure of material; there is no provision for the resumption of land outside reserves; there is no real organization enacted to cope with this whole problem and and there is no adequate provision for the control and organization of archaeological research in the Northern Territory. [1975: 24]

He called for new legislation to be implemented by an expert body, to include Aboriginal representation and to make provision for the control of archaeological excavations; this proposed replacement legislation was to be based on the original Western Australian bill (Jack-Hinton, 1975: 24–27). Nothing came of this and the 1955–1960 ordinance is still in force. Originally, the ordinance was administered by the Welfare Branch, Northern Territory Administration, Department of Territories (Mills, 1977: v) but with the changes in administration of the Territory in 1979 their task transferred to the Museums and Art Galleries of the Northern Territory in Darwin.

In 1978 new legislation, dealing with one aspect of the management of sites, was proposed. This is considered below.

*Aboriginal Sacred Sites Act* 1978

This act, originally an ordinance under the old administration, (Number 115 of 1978) and its *Amendment Act* (Number 116 of 1978) came into force in September 1979. The focus of this legislation is exclusively upon 'sacred sites' in the Northern Territory. It defines a sacred site as

> . . . a site that is sacred to Aboriginals [sic] or is otherwise of significance according to Aboriginal tradition, and includes any land that, under this ordinance, is declared to be sacred to Aboriginals or of significance according to Aboriginal tradition; [Section 3]

In order to implement the legislation, the Aboriginal Sacred Sites Protection Authority was established; it consists of 12 members, all except the Director being appointed by the Administrator, including at least seven Aborigines nominated by the Land Councils, and others 'experienced in anthropology, land use and survey, Aboriginal studies, site conservation or other such fields as the Administrator thinks fit' (Section 4). The functions of the Authority are

> (a) to establish and maintain a register of sacred sites;
> (b) to examine and evaluate all claims for sacred sites made to it by Aboriginals;
> (c) record sacred sites, with full details of the significance to the traditional Aboriginals, including any story, of each sacred site and any relevant factors including custodianship of the sacred site;
> (d) to recommend to the Administrator that particular sacred sites be declared protected sites . . . [Section 13]

The Register of Sacred Sites is to detail the boundaries of the sacred sites, the names and addresses of the custodian(s), the traditional history of the site and any other relevant material. The register is not a public facility; access is at the discretion of the Authority (Section 24).

A custodian of a sacred site may seek to have it declared as such for the purposes of the ordinance. The Authority 'may, if it thinks fit', apply to the Administrator to have the site so declared and the Administrator must evaluate the importance of the site and the implications of making such a declaration (Section 26). When an area is declared a sacred site (Section 27) by gazetting—to include a map of the area and notification of steps taken to protect the site—the Authority has powers to protect the site. It may acquire land, reserve Crown Land, have title to Crown Land vested in it; it may then manage that land; it may assist a landholder with funding for special measures to protect sites on his land (Section 28) and it may advise the Administrator in the appointment of honorary wardens (Section 30) whose reasonable directions relating to the protection of a sacred site must be obeyed (Section 31). The Authority and the custodian of the sacred site may permit entry onto a protected area subject to any conditions the Authority wishes to impose (Section 29). It is an offence to knowingly desecrate a sacred site but it is possible to 'carry out works on a sacred site' with the written permission of the Authority (Section 31).

This act is part of the 'complementary legislation' brought in by the Northern Territory Legislative Assembly in 1978 to accompany the federal *Aboriginal Land Rights (Northern Territory) Act 1976* (No. 191 of 1976). It is useful to consider the Sacred Sites Act in conjunction with the Land Rights Act since the latter provides a point of departure for the former (see particularly Section 73(i) of that act). Section 69 of the Land Rights Act deals with entry to sacred sites; it states, *inter alia*, that:

> Except in the performance of functions under this Act or otherwise in accordance with this Act or a law of the Northern Territory, a person shall not enter or remain on land in the Northern Territory that is a sacred site.

There is a defence requiring the person to demonstrate that he had 'no reasonable grounds for suspecting that the land concerned was a sacred site' (Section 69(3)) but this defence:

> shall not be taken to have been established by a person unless he proves that—
> (a) his presence on the land would not have been unlawful if the land had not been a sacred site; and
> (b) he had taken all reasonable steps to ascertain the location and extent of the sacred sites on any part of that Aboriginal land likely to be visited by him.

While there are potential difficulties with this section, for example, if an authority holding information relating to the localities of such sites is unable or reluctant to make it available, it is clearly necessary for the researcher to familiarise himself with this aspect of his study area.

There are further restrictions upon entry to Aboriginal land of which the archaeological researcher should make himself aware (see, for example, Sections 70 ff.).

Clearly, too, this new legislation complements the existing *Native and Historical Objects and Areas Preservation Act 1955–1960* rather than surplants it. Its importance for archaeologists resides in the fact that entry onto 'protected areas' is proscribed and thus anyone conducting a survey should know if there are any such areas within the range of the proposed survey and, if so, either avoid them or obtain permission to enter the areas. While systematic archaeological excavation is not mentioned in Section 31, neither is it excluded in the term 'works' in Subsection 4; presumably, it is possible to apply for permission to carry out excavation under this section. Since custodians of sites have to be consulted and the Authority, composed of members drawn from all parts of the Territory (Everingham, 1979), appears to have to meet to consider such requests, reasonable time should be given for the Authority to respond to a request for permission to enter upon or excavate within a protected area (the Authority is required to meet as often as is necessary to carry out

its functions and at least every three months—Section 9(2)).

*Summary*

Two pieces of legislation specifically and primarily concerned with Aboriginal sites are in operation within the Northern Territory, the first dealing more with relics, the second with sacred sites; the *Aboriginal Land Rights Act* has some related provisions. The archaeologist considering work in the region needs to be aware of their provisions relating to the entry onto certain lands, the handling of certain 'prescribed' objects, the rights of traditional custodians and the authority of honorary wardens. It would appear that the provisions of the Sacred Sites legislation are particularly broad dealing with, firstly, sites not specifically defined, secondly, sites included in the Authority's Register and, thirdly, areas formally declared as sacred sites.

A pamphlet entitled *Archaeological Sites in the Northern Territory, Information for Planners and Developers* is available from the Museum in Darwin; it contains material which will be of value to the archaeological researcher as well. The first *Annual Report* of the Aboriginal Sacred Sites Protection Authority is now available; it gives some insight into the activities of that body and outlines some projected changes to the legislation (page 9). A discussion by the head of the Authority on sacred sites and objects was read to a recent meeting of the council of ministers of Aboriginal affairs (Ellis, 1981).

## South Australia

The South Australian *Aboriginal and Historic Relics Preservation Act,* after being assented to in December 1965, finally came into operation nearly two years later in August 1967. The act aims to provide protection for Aboriginal relics by reserving land on which they occur and controlling access to that land and any trade in relics. The Minister is nominally the administrator of the act; initially this was the Minister of Education, and the Protector of Relics (Section 3) was the Director of the South Australian Museum. Subsequently, the responsibility was taken by the Minister for the Environment and in 1970 an authority separate from the Museum was established—the Aboriginal and Historic Relics Unit. With a change of government, the AHRU was absorbed within the Heritage Unit of the Department for the Environment in April 1980; about this time there was much discussion of the role of the Unit and its staff in the popular press (for example, Tilbrook & Ball, 1980).

In 1979 controversial new legislation was enacted but, at the time of writing, it had not yet been proclaimed. The new legislation—*The Aboriginal Heritage Act, 1979*—repeals the 1965/67 act but, clearly, since the older act is still in force, both must be considered here. It would appear that the state government's intention is to proclaim the 1979 act sometime in 1982 but there is no indication when this will be done; consequently, the later act, as it stands at present, is also discussed here. It seems likely, also, that some amendments to it will be made at the same time and the reader should keep this in mind throughout the following discussion.

*Aboriginal and Historic Relics Preservation Act of 1965*

The intention of the act is to protect 'Aboriginal relics' by gathering knowledge about them, by reserving areas of land, empowering inspectors and wardens to control access to those areas and to prevent damage and trade in relics. A minister of the government has this responsibility; he is to be advised by a board of people serving in an honorary capacity appointed by him and to consist of representatives nominated by the Council of the University of Adelaide, the Ministers administering the Departments for the Environment and for Community Welfare and the Department of Lands, 'whose representative shall be the member of the Pastoral Board nominated by land holders' (Section 6(2) as amended by proclamation in January 1976). The act is implemented by a 'Protector of Relics' who is the Director, Department for the Environment (Section 7 as amended by proclamation in January 1976) with powers of delegation (Section 8). The Director and members of the police force have the power of 'inspectors' (Section 9) that is, to:

> search for, inspect and examine any relic; seize any relic . . . and require any person reasonably suspected as likely to damage a relic to leave a historic reserve

and including the powers of arrest (Section 12).

The Protector of Relics is required to:

> Keep a complete register of all reserves, prohibited areas and unproclaimed known occurrences of relics and regularly inspect and report annually upon their preservation [and to] actively search for, and seek information in relation to any new discovery of relics and arrange for the adequate protection of any new such discovery. [Section 10]

A relic is defined as (a) 'any trace, remains of handiwork of an Aboriginal' (excluding that made for sale) and (b) 'any trace or remains of the exploration and early settlement . . .' of importance (Section 3). It appears that the latter is intended to refer exclusively to European material.

The major way in which a relic can be protected is by reservation of the land on which it stands. Under a number of conditions then, any land can be proclaimed a 'prohibited area' (Section 16) or an 'historic reserve' (Section 17). The Governor may by proclamation declare land to be a prohibited area if he is satisfied that:

> (a) it is expedient to reserve that land for the preservation of relics; and
> (b) for such preservation it is necessary to prevent the entry of persons onto that land; and
> (c) satisfactory arrangements have been made or will be made for the management of the land as a prohibited area and for controlling the entry of persons into the land; and
> (d) the consents required by the Act have been obtained. [Section 16]

The last requires that the Minister give his recommendation where Crown Land is involved and that approval be obtained of the occupier and owner of private land (Section 18).

An historic reserve, by comparison, may be proclaimed

> If the Governor is satisfied with respect to any land that—
> (a) the land is or may be used for purposes other than the preservation of relics, but that it is desirable to preserve relics thereon as far as is practicable having regard to the other uses of the land; and
> (b) the consents required by this Act have been obtained, . . . [Section 17]

so that while entry is not prohibited, the type of use made of the land may be restricted so as to afford some degree of protection to a relic within the area concerned by reserving land under these sections.

Prohibited areas and historic reserves may be signposted and it is an offence to interfere with such a notice (Section 20). All relics within reserved land are deemed to be the property of the Crown and under its protection (Section 21); it is an offence to go within a prohibited area without permission from an 'authorized person'—that is, for Crown Land, the Minister and for private land, the Minister or the occupier or his delegate (Section 22). Under certain

conditions the Governor, at the request of the owner of land on which an historic reserve has been proclaimed, can reverse that decision; the Governor can, anyway, 'revoke or vary . . . any proclamation declaring land to be a prohibited area or historic reserve' (Section 24).

It is an offence to:

> . . . wilfully or negligently deface, damage, uncover, expose, excavate or otherwise interfere with any relic in an historic reserve or to carry out any act likely to endanger the relics thereon except with the written permission of the Minister. [Section 23]

but not, surprisingly, on a prohibited area—presumably the latter are thought to be covered adequately by controls on entry. Under certain conditions, the Minister may 'direct the excavation or examination of an historic reserve and the removal of any relics from it to safe storage' (Section 24) but, again, not explicitly for a prohibited area and it is not an offence 'to pick up or collect any portable relic exposed in or upon the surface of any land' although any one doing so is obliged to safeguard it from loss or damage and cannot sell it without the consent of the Protector (Section 27). Generally, it is an offence to:

> . . . knowingly conceal, destroy, deface or damage a relic of the nature of cave paintings or rock engravings or stone structures or arranged stones or carved trees of Aboriginal origin. [Section 28(1)]

That is, a limited range of sites on areas outside reserved land are protected but apparently not others, such as middens or any other subsurface deposits. The only condition, it appears, for anyone digging over a site outside reserved land is that they report their finds of relics (Section 28(2)).

Consequently, an archaeologist's responsibilities under this legislation are not entirely clear. It would seem that he may make archaeological surveys, surface collections and excavations anywhere outside reserved land without offending the act, as long as he reports the knowledge of any relic within an unspecified time; certainly there is no condition made explicit in the act that archaeologists report their findings in an academic sense. No collection or excavation may be done within historic reserves without the Minister's permission. Entry may not be made onto prohibited areas without permission and, presumably, although it is not explicit, this would prevent collection or excavation of 'relics'. On the other hand, the Governor may make regulations to enable the implementation of the act (Section 34) and it is possible that these matters are covered elsewhere.

*Aboriginal Heritage Act, 1979*

The as yet unproclaimed 1979 act sets out to be more comprehensive and, in generalising, is less comprehensible than the 1965 legislation. The new act differs in significant respects from the old. Firstly, there are changes in the various definitions made in the first part. Importantly, an 'Aboriginal site' is defined as 'any area of archaeological, anthropological, ethnological, or historic significance relating to the Aboriginal people'; a new term 'item' replaces 'relic' and is defined as

> (a) any Aboriginal artefact or handiwork, including any tree or rock face apparently marked in a traditional manner by an Aboriginal person [but not made for sale];
> (b) any traces of Aboriginal culture;
> (c) any Aboriginal remains of archaeological or anthropological interest.

The dual 'historic reserve' and 'prohibited area' are replaced by 'protected area', and the concepts of an official 'register', a 'registered Aboriginal site' and a 'registered item' are introduced (Section 6).

Among his general administrative duties, the Minister is now responsible for (a) causing searches to be made for items of information about sites or items, (b) keeping a register of Aboriginal sites and items, and (c) taking practical measures for the protection and preservation of Aboriginal sites and items (Section 7).

A separate Treasury fund is to be established to assist the implementation of these objectives (Section 8 and 9). An 'Aboriginal Heritage Committee' is to be established to replace the earlier 'Board'; it is to have nine members, three of whom are to be Aborigines, one a nominee of the Board of the South Australian Museum and one a nominee of the Pastoral Board; they are to be appointed by the Governor rather than the Minister (Sections 11 to 15). Among the responsibilities of the new Committee are:

> (a) to recommend the registration of items or Aboriginal sites;
> (b) to recommend to the Minister the declaration of protected areas;
> (c) to recommend the acquisition of items that in their opinion warrant acquisition; . . .

and in these considerations:

> Aboriginal sacred beliefs and ritual and ceremonial usage shall, in so far as they can be ascertained, be regarded as the primary consideration to be taken into account . . . [Section 16]

There are to be 'inspectors' but not 'wardens' under the new act; they will be (a) members of the Police Force and (b) others appointed by the Minister; they may attempt to prevent offences against the act, require people to leave protected areas and seize items (Sections 18 to 20). Presumably, those people previously made honorary wardens under the old act will be made inspectors under the new law so that much local expertise and goodwill can be retained.

Under certain circumstances, the Minister will be able to declare (by gazetting) an Aboriginal site as a 'protected area'; it will be then an offence to 'enter, or use, a protected area in contravention of a restriction contained in a [gazetted] notice' and a substantial fine ($10 000) or imprisonment may result from conviction (Section 21). These provisions presumably will apply to Crown Land as well as private land although this is not made explicit.

Sites and 'items' will be protected by a wider series of provisions detailed in Section 25 to 27. An archaeologist but not a backhoe operator, for example, is prevented from digging up *any land*—either within or without a protected area—without the permission of the Minister unless, presumably, it can be shown that the operator was fossicking:

> A person shall not, without the consent of the Minister, excavate any land for the purpose of exploring for an item of the Aboriginal heritage . . . [Section 25(1)]

Further, anyone may collect items from freehold land outside a 'registered Aboriginal site' or 'protected area' (Section 25(2 and 3)) if he takes reasonable care of them (Section 25 (4)) and does not sell them without the Minister's consent (Section 25(5)).

In order to expedite the diminution of items of 'the Aboriginal Heritage' in secure contexts, to diminish the proportion of unmined land and to decrease unemployment amongst archaeologists, qualified or otherwise, the Minister may expedite excavation anywhere:

> Where the Minister has reason to believe that items of the Aboriginal heritage may be lying upon or under any land, he may, by instrument in writing, authorize any person to enter and excavate the land (either within or outside a protected area) and to remove any items to safe storage. [Section 26(1)]

Of course, it is necessary to give the landholder reasonable notice in advance (Section 26(2 and 3)); the Minister will then compensate for any damage done to the land (Section 26(4)).

An item, if the Minister gets to know about it and formally registers it, may not be damaged or destroyed (Section 27(1)) unless the possessor can show that he was not doing so on purpose (Section 27(2)).

Some sections of the new act would appear to offer only marginal provision for the protection of sites and other items from negligent or intentional destruction or loss. However, the archaeologist, or the researcher in his charge (anyone 'excavating any land for the purpose of exploring for an item of the Aboriginal heritage'—Section 25(1)), has some obligations. He shall (as must others) report, 'forthwith', to the Minister the discovery of any item (Section 28); although, having surrendered any item to the Minister as might be required (Section 29(1)), he can have it back again after four months (Section 29(2)).

Since the new act makes no provision for the automatic inclusion of all previously defined 'historic reserves' and 'prohibited areas' in the category of 'protected areas' under the new legislation, it is to be hoped that they are already redefined and regazetted by the time that the new act comes into operation. If not, then they are presumably open for collection at, if not excavation into (unless on freehold land), for any interim period by the archaeologist and fossicker alike.

*Summary*

The archaeologist contemplating work in South Australia should ascertain which of the two pieces of legislation outlined here is in operation before he commences work; he should also check to see if any substantive changes have been made to the newer act before its commencement, as it would appear that the necessity for these is being considered.

Among the few documents available concerning the legislation and its implementation is one written for the Department of Mines and Energy and entitled *Aboriginal Sites in South Australia* (Mineral Information Series). There are also a general discussion by the previous head of the AHRU of *Aboriginal Culture in South Australia* (Ellis 1978) and useful articles on particular types of sites in the 'Notes on South Australiana' series (Anon. 1979a, 1979b). An earlier outline of the aims and procedures of the AHRU which might still be of value for its description of the availability of site locality data, the method of registering sites and its instructions for preparation of a site report might still be available (Ellis 1977).

## Queensland

The *Aboriginal Relics Preservation Act* of 1967–1976 came into operation in May 1968; it was last amended in 1976. It was, thus, one of the initial group of systematic state legislations following upon the example of the previous decade set by the Northern Territory administration. Prior to this, sites in National Parks were afforded some protection by the Forestry Act 1959–1971 (Section 41) and this still affects areas of parks and reserves.

The Relics legislation has three basic aims; in the public interest, it sets out (*a*) to protect all traces and remains of Aboriginal culture throughout the state; (*b*) to preserve such remains through scientific action and public education; (*c*) to regulate archaeological investigation. The emphasis is clearly upon the material *remains* of a culture, one which has not met with the approval of the state's Aboriginal communities. The minister of the Crown administering the act—currently the Minister for Aboriginal and Islanders Advancement—has broad powers to act in the public interest. The Archaeology Branch of the DAIA was established in 1971 to implement the provision of the act.

An 'Aboriginal site' is defined in a legalistic sense and tautologically as:

> An area of the State for the time being declared as an Aboriginal site or a temporary Aboriginal site or reserve or otherwise acquired by the Crown for the preservation or protection of a relic;

'relics' are:

> Any Aboriginal remains and any traces, remains or handiwork within the State of Aboriginal culture [except those made for sale]. (Section 3)

All Aboriginal relics (unless excluded by Section 18) on both private and Crown Land are the property of the Crown and are protected by the legislation without needing to be further specified; they may not be disturbed without a permit issued by the Minister. To preserve a relic an area of land can be reserved under certain conditions and access to the area be controlled.

The act is administered by a minister and, subject to him, the Director of the Department of Aboriginal and Islanders Advancement. There are two categories of officers under the act—inspectors and wardens. The Director, Deputy Director and district officers of the department have the powers of Inspectors although these are not necessarily restricted to senior officials (Sections 5 and 6). An Inspector's powers are widely defined, since he may act against people found committing, or suspected of committing, an offence under the act; they include powers of arrest and entry of any place except a residence without requiring a warrant (Section 7). Wardens serve in honorary capacities and have some of the powers of Inspectors but usually in relation only to sites and relics in particular areas. A large part of the recent amendments strengthens this section and increases the penalties for offences regarding assault, failure to comply with requests and resisting Inspectors and Wardens (Section 8). Aboriginal Rangers also are employed by the Archaeological Branch.

Unlike most other state legislation, there is no explicit requirement to keep a register of sites or artefacts or to carry out research or activity to protect sites and artefacts.

The act requires the formation and gathering of an Advisory Committee comprising the Director of the Department of Aboriginal and Islanders Advancement, the Professor of Anthropology and Sociology at the University of Queensland, the Director of the Queensland Museum and others nominated* by the Minister (Section 9). The Committee is to advise him on:

> (a) the anthropological value and significance of a relic or of an area which is such that it might be declared as an Aboriginal site;
> (b) the desirability of declaring an area as an Aboriginal site or of resuming or otherwise acquiring an area for preservation as an Aboriginal site or of acquiring a particular relic;
> (c) the extent of an area which, in a particular case, should be declared . . . ;
> (d) all other matters pertinent to the objects of this Act. [Section 12]

The Governor, by Order in Council, may declare, or revoke the declaration of, an area as an Aboriginal site, under certain conditions, for the protection of a relic (Section 13). Important among the conditions are the consents required: that of the relevant Ministers for Crown and forestry lands and the occupier and/or owners of private land (Section 14).

Subject to the interests of Aborigines and with certain exceptions, all relics are defined as the property of the Crown and

* Changes in the formal constitution of the Relics Advisory Committee have been gazetted (6 June 1981) and now the Minister merely *appoints* all members; since that time all previous members, except the person in the position for the Professor of Anthropology at the University of Queensland, have been re-appointed.

this includes as yet unexcavated archaeological materials (Section 18).

It is an offence to be on a declared Aboriginal site without permission; for Crown Lands this can be obtained from the Minister or his delegate and for private lands from the Minister and the occupier or attorney of the occupier. Such permission does not authorise a person to interfere with relics and it may be granted subject to conditions (Section 19). Interference with relics is explicitly prohibited:

> A person shall not take, deface, damage, uncover, expose, excavate, cover or conceal or interfere with or be in the possession of a relic the property of the Crown or, upon an Aborginal site, do any act likely to endanger any relic thereon or thereunder unless—
>
> (a) he is thereunto authorized under the Act; or
>
> (b) he does not know or suspect the same to be a relic. [Section 20(1)]

The Minister, however, may cause (Section 21(1)) or permit (21(2)) relics to be excavated and removed to safe storage and

> A person who desires to perform excavation, examination or research of or upon an Aboriginal site or in respect of any relic shall apply in writing to the Minister for his authority to do so and shall, in connection with such application, furnish to the Minister such information as the Minister requires.

The Committee, in recommending upon such an application is required to consider:

> (a) the qualifications of the applicant to properly attain the purpose to which such application relates;
>
> (b) the desirability of carrying out excavation . . . ;
>
> (c) the financial resources of or available to the applicant and his ability to attain the purposes to which such application relates;
>
> (d) all other matters which the committee considers to be relevant to such application. [Section 21(2)]

The final decision with respect to permits rests with the Minister; a written authority to excavate will specify the person to whom it is granted and the particular site concerned; it will not have any authority over private land unless the occupier and owner also provide written consent to the granting of a permit; it will be valid for 12 months and be renewable (Section 21(3)). The researcher's rights of access to the site for himself, assistants and equipment are specified in Subsection 21(4). The permit may be revoked by the Minister at 28 day's notice unless the applicant can show cause why it should not (21(5)). Anyone carrying out research is obliged to provide the Minister with a copy of any report 'as soon as possible after publication' (21(6)).

Any researcher who, with the appropriate authority, collects a relic must surrender it to the Director for inspection and classification by the Committee and decision as to whether it be retained by the Crown (Section 22). This section does not allow it to be assumed, however, that excavated materials relinquished to the care of the Crown will automatically be lodged within a state museum and the archaeologist may need to take the responsibility upon himself to see that this is done.

Anybody who knows of the existence of 'any thing in the nature of Aboriginal burial grounds, cave paintings, rock engravings, stone structures, arranged stones, or carved trees which he knows or expects to be a relic' must report this to an Inspector (Section 23). This section is interpreted to include all other types of relics.

The 1976 amendments empowered the courts to direct that, not only a fine for damages be incurred by the guilty party but also, the party be required to make payment to the Director of a sum to enable the restoration of the relic concerned.

### *Summary*

While the Queensland legislation has been criticised for being assimilationist and serving White aims, for failure to consult with Aborigines and ignoring their wishes, for failure to protect sites due to the strict requirements of the consents of other interested parties and the reluctance of the authorities to prosecute transgressors (it appears that major amendments are at present being mooted and should they include provision for sites of significance to contemporary Aboriginal communities, it is possible that some of these criticisms may be met) it would seem that the control it affords of archaeological activities is unquestioned.

The intending researcher should note that the Advisory Committee must consider all applications for permits and that reasonable advance notice should be given. While the Committee advises the Minister on the issue of permits, the Minister may or may not act upon this advice. Requests should be directed to the Officer-in-Charge, Archaeology Branch, Department of Aboriginal and Islanders Advancement. The Committee has recommended the grant of permits to amateur, student and professional researchers for both site survey and excavation; they are valid for up to one year, and normally are granted for area-specific projects; while permits are renewable, the same conditions must be met as pertain to the original application.

The Archaeology Branch has a number of publications which will be of interest to the intending researcher; these include two brochures, *For your information* and *The Preservation and Protection of Queensland's Cultural Heritage*, and the occasional *Honorary Wardens' Newsletter*. As well there are the *Annual Reports* of the Department of Aboriginal and Islander Advancement.

An earlier description of the Queensland legislation (Killoran, in McCarthy, 1970) and papers concerning the priorities of the implementation of the legislation by the present Officer-in-Charge of the Branch (Sutcliffe, 1978, 1979) will be of interest. Critical analyses of the legislation and its implementation have been made by Gordon (1979), Robins (1979) and Trigger (1979).

## New South Wales

The relevant legislation applying in the country's most populous state is that administered by the New South Wales National Parks and Wildlife Service. The initial NPWS act dates from 1967. A consolidating and amending *National Parks and Wildlife Act* was assented to in November 1974; this is the version in operation at present, although changes have been mooted which will affect that part related to Aboriginal materials.

The *National Parks and Wildlife Act, 1974* sets out to protect sites by the definition of 'Aboriginal areas', 'places' and 'protected archaeological areas' and by restricting access to and use of these areas. It defines a 'relic' as:

> any deposit, object or material evidence (not being a handicraft made for sale) relating to indigenous and non-European habitation of the area that comprises New South Wales, being habitation both prior to and concurrent with the occupation of that area by persons of European extraction. [Section 5(1)]

The Director of the Service is obliged to consider and may investigate proposals for reserved areas. He is to take into account various factors including whether relics or Aboriginal places of special significance are present and he may undertake such scientific research as he considers necessary for the preservation, protection, management and public education concerning those areas. He is obliged, in consultation

with the Australian Museum to assess the scientific importance of newly discovered relics (Section 8). Further, the Service must carry out:

> such works and activities as the Minister may direct . . . for the preservation and protection of . . . historic sites, . . . and the prevention of damage to, relics and Aboriginal places in national parks, historic sites, nature reserves, Aboriginal areas and protected archaeological areas and for the exploration of lands with the object of discovering relics. [Section 12]

The roles of *ex-officio* and honorary Rangers are defined; they have powers to protect relics and archaeological areas (Sections 16 to 20).

The Minister or the Director is to be advised by a Relics Committee:

> on any matter relating to the preservation, control of excavation, removal and custody of relics or Aboriginal places. [Sections 27 and 28]

Until recently, the Relics Committee consisted of eight members appointed by the Minister and comprised experts drawn from the staff of (*a*) a university within New South Wales and (*b*) the Australian Museum, the memberships of (*c*) the Anthropological Society of New South Wales and (*d*) the National Trust of Australia (NSW), and an officer each of the Department of Mines and the NPWS (Schedule 9). In late 1980, this committee was replaced by the Interim Aboriginal Sites Committee, which consists of six Aboriginal members, appointed by the Minister from amongst the Aboriginal communities of the state, and professionals drawn from the Service's Aboriginal and Historic Resources Section, the Australian Museum, universities and elsewhere. The new committee meets at two-monthly intervals to make recommendations to the Director of the Service concerning the management of Aboriginal sites in the state and will consider and recommend on the granting of permits and consents for the collection, disturbance, excavation, recording and destruction of sites. Researchers are advised to make applications for permits to the Service (addressed to the Director, marked for the attention of Ms S. Sullivan) at least two months before the proposed commencement of the work, since the Committee could decide that some investigation of proposals could be required (Sullivan, personal communication, 1981).

For the purpose of preserving, protecting and preventing damage to relics or Aboriginal places within an Aboriginal Area, 'Aboriginal Areas' and 'Protected Archaeological Areas' (PAA) may be declared subject to certain conditions (Sections 62 and 65). The former may involve Crown Land only (although the Director can resume or purchase private land); PAAs may be declared on private land with the consent of the owner and occupier but may be revoked at any time—at, for example, the request of the person whose consent is required (Sections 62 to 65). The Director may regulate entry into and use of a PAA with the required consent of relevant people (Section 66). Management of an Aboriginal Area may be affected by a Plan of Management (Section 77).

Certain relics are declared to be the property of the Crown (Section 83). As well as Aboriginal Areas and PAAs, 'Aboriginal Places' may be declared; one 'being a place that . . . is or was of special significance with respect to Aboriginal culture . . . ' (Section 84). The Director is then responsible for preservation and protection of relics or Aboriginal places which are within a national park or other reserved areas and, in some cases, for restoration of such areas where they have been excavated for the purpose of discovering a relic (Section 85).

Generally, it is an offence to disturb or excavate any land for the purpose of discovering a relic, to disturb or to move any relic which is the property of the Crown or to remove a relic from a reserved area such as an historic site or Aboriginal area, except with an appropriate permit. Thus, any person who:

> (a) disturbs or excavates any land, or causes any land to be disturbed or excavated, for the purpose of discovering a relic;
> (b) disturbs or moves on any land a relic that is the property of the Crown, other than a relic that is in the custody or under the control of the Australian Museum;
> (c) takes possession of a relic that is in a national park, historic site, nature reserve or Aboriginal area;
> (d) removes a relic from a national park, historic site, nature reserve or Aboriginal area; or
> (e) erects or maintains, in a national park, historic site, nature reserve or Aboriginal area, a building or structure for the safe custody, storage or exhibition of any relic, [except as authorized] is guilty of an offence against this Act. [Section 86]

Such authorisation might be obtained from the Director, subject to a variety of terms and conditions (Section 87). Generally, the Service and the Australian Museum have responsibility for the custody of relics (Section 88). While some relics might remain in the possession of private persons, the Director may, by agreement with that person, acquire the relic or Aboriginal Place for the purposes of its preservation or exhibition (Section 89).

It is an offence to knowingly destroy, deface or damage a relic or Aboriginal place and substantial penalties are provided for (Section 90). Anyone knowing of the location of a relic (not in private possession) must notify the Director (Section 91).

*Summary*

The implementation of the New South Wales legislation is the responsibility of the Aboriginal and Historic Resources Section of the National Parks and Wildlife Service. The Section has prepared a booklet, *Aboriginal Sites in N.S.W.: For Planners and Developers*, which contains a number of case studies, describes a range of sites and relics and outlines the legislation, stressing the obligations of local councils and of developers. Many of these obligations also apply to archaeologists. Another recent publication of this Section is entitled *Aborigines of New South Wales*; it contains discussions of various types of sites and relics, some brief historic studies, popular accounts of Aboriginal adaptations in various parts of the state, along with a discussion of the role of the Service in dealing with Aboriginal relics and an outline of the legislation (Haigh & Goldstein, 1980).

Major points to be recalled by fieldworkers starting an archaeological survey or contemplating excavation in New South Wales are these:

(a) Relics are generally the property of the Crown.
(b) Relics may not be collected or disturbed whether on Crown or freehold land without authorization.
(c) Anyone discovering a relic is obliged to report the discovery to the Director, NPWS.
(d) It is an offence to disturb, damage, deface or destroy a relic or Aboriginal place.
(e) Entry onto some areas may be prohibited.
(f) No excavation, for the purpose of discovering a relic, on Crown or freehold land, may be done without authorization by the Director of the National Parks and Wildlife Service.

### Australian Capital Territory

No protective legislation has been proclaimed in the ACT. There has been gazetted an ordinance, the *Nature Conservation Ordinance 1980,* which states in part that:

> A person shall not, in a reserved area, without the consent in writing of the Conservator—
>
> (b) damage or destroy a site, or remove an object, of historical, archaeological, palaeontological or geological interest.
> Penalty: $500. [Section 56(3)]

It would apply only to National Parks and other reserved areas; neither 'site' nor 'object' is defined. At the time of writing, the ordinance had been further delayed.[1]

### Victoria

The relevant Victorian legislation is the *Archaeological and Aboriginal Relics Preservation Act 1972* as amended in 1980. The legislation attempts to provide for the preservation of archaeological and Aboriginal relics by recording and researching sites and other relics, including private collections, proclaiming and administering archaeological areas and by public education.[2]

The recent amendments to the primary act deal mainly with administrative concerns and substantive matters are restricted to (*a*) the broadening of the definition of relic to include an artefact from any part of Australia rather than Victoria alone, (*b*) the explicit definition of the National Museum of Victoria as the official repository of relics which are the property of the Crown, and (*c*) the requirement that a researcher notify the authorities of the intention to undertake an archaeological survey. The definition of a relic now reads as follows:

> 'Archaeological relic' or 'relic' includes a relic pertaining to the past occupation by the Aboriginal people of any part of Australia, whether or not the relic existed prior to the occupation of that part of Australia by people of European descent, and without affecting the generality of the foregoing, includes any Aboriginal deposit, carving, drawing, skeletal remains and anything belonging to the total body of material relating to the past occupation of Australia, but does not include a body or the remains of a body interred in a cemetery, burial ground or a place of burial after the year 1834, or a handiwork made for the purpose of sale. [Section 2]

The Minister for Conservation is responsible for the administration of the act and the Director of Conservation (previously a 'Protector of Relics') is required to keep registers of all archaeological areas, known occurrences of relics and of private collections of relics, to conduct research and to protect relics, to manage protected areas and to develop educational programmes (Sections 4 and 10).

The Minister is to be advised by an Archaeological Relics Advisory Committee comprising the Director of Conservation and eleven other members drawn from the National Museum, a Victorian university, the membership of the National Trust and the Archaeological and Anthropological Society of Victoria, the Australian Institute of Aboriginal Studies, three government authorities (Lands, Forests and National Parks) and three Aborigines (Section 5).

Honorary inspectors and wardens may be appointed by the Governor in Council; unless limited, inspectors and wardens have the power to question suspects, seek information concerning relics, impound relics and require persons in an archaeological area to leave the area (Sections 9, 11 to 14).

The Governor may reserve land in order to protect relics and thus restrict the right of entry onto that land; the consent of Ministers is required for Crown Land and of the occupier and/or owner for private land. A 'temporary archaeological area' may be gazetted without such consent (Sections 15 and 16). It is an offence to be within an archaeological area without the permission of an authorised person; relevant Ministers may give approval for entry onto Crown Land and the owner or occupier or his delegate may authorise access to private land (Section 17). The Governor may revoke declaration of an archaeological area at the request of the owner of the land on which it occurs or at his own discretion; the Minister, however, may direct the removal of any relics on or under the land to safe storage if this is done (Section 24).

Certain relics are deemed to be the property of the Crown—those within proclaimed archaeological areas—and the National Museum of Victoria is nominated as the official place of lodgement for safe storage of such relics (Section 20).

Either within or without an archaeological area it is an offence to wilfully or negligently deface, damage or otherwise interfere with a relic (Section 21) and to disturb or excavate any land for the purpose of uncovering or discovering a relic without the consent of the Minister (Section 22). The Minister may grant an applicant a permit for this purpose subject to any conditions he wishes to impose and, moreover, may require the examination and excavation of an 'archaeological area' and the removal of any relics there to safe storage (Section 22). Such authorisation is not necessary in order to conduct an archaeological survey but, in a recent addition to the act, the researcher is required to notify the Director before and after such a survey:

> Any person who undertakes an archaeological survey of any land shall—
>
> (a) notify the Director of his intention to undertake a survey prior to the commencement of the survey; and

---

[1] The ACT ordinance (Number 20 of 1980) was enacted in June 1982 with the Nature Conservation (Amendment) Ordinance 1982 (Number 22 of 1980); Section 56(3) was not changed. No Nature Conservation Areas, in which the ordinance would apply, had been gazetted at the end of 1982. Discussions continue on the necessity for more adequate legislation.

[2] The *Archaeological and Aboriginal Relics Preservation Act* is likely to be further revised following discussion of the Archaeological Relics Advisory Committee's report *Aboriginal Sacred and Significant Sites* which was released for public distribution and comment in September 1982. As indicated by its title, the report deals with places of significance to Aborigines and details mechanisms by which sites may be 'claimed'. It proposes that a area of public or private land could be declared an 'Aboriginal Area' or 'Place' and recommendations for the positive management and protection of declared areas are made. The land would be given status similar to an area of the Australian Heritage Commission's Register of the National Estate; its use could be restricted and covenants could be placed on the land for its protection, maintenance and accessibility; land could be acquired and reserved.

> In the case of a Place the Government would have a similar set of commitments to protect, maintain, and preserve the Place as currently exists for declared Archaeological Areas.
>
> In the case of an Area the Government would be responsible for ensuring against the destruction of the Area, and would take all reasonable steps to ensure that appropriate and acceptable prescriptions are drawn up for the management of an Area, be it on private or public land. [Section 7(1 and 2)]

A register of Places and Areas is to be maintained (Section 4(4ff.)). These provisions have clear implications for the archaeological researcher who will have to follow the progress of the proposed legislative changes including those to be embodied within a

> forthcoming *Aboriginal Land Rights Bill* which allows for claims to be made to public land on the bases of cultural, communal or economic needs; historical association; traditional rights, and/or compensation for dispossession of traditional rights. [Moore, personal communication]

(b) provide all site information collected in the survey to the Director in the prescribed form. [Section 22(5)]

Further, any person who discovers a relic must report this to the Director or to an inspector or warden; if such a discovery is made in the course of any construction or excavation of land it must be reported immediately and the Director, if he considers the relic worthy of preservation, shall take appropriate action (unless otherwise directed by the Minister in consultation with the Advisory Committee).

While it is not an offence to collect a portable relic exposed in or upon the surface of the land, anyone doing so must safeguard it from loss or damage, ensure that it can be identified and advise the Director, describing the relic and where it was found; no portable relics may be bought or sold without the written consent of the Director (Section 27).

*Summary*

The Victorian act is implemented by the Victoria Archaeological Survey. The Survey has produced a number of publications with advice for developers and archaeologists. In a leaflet entitled *The Protection and Preservation of Aboriginal Relics* it outlines the significance of relics, whose responsibility it is to preserve them, how they are protected, the role of the interested layman in this area and 'what to do when you find a relic'. A more substantial pamphlet also sets out to provide a guide for planners and developers (Coutts, 1977). Of more interest to researchers will be another pamphlet which provides a guide to the structure and activities of the survey, *Custodians of our Past*, while a recent paper by its present director summarises the aims, implementation and progress of the Survey's site recording programmes (Coutts, 1979). Archaeologists contemplating work in Victoria should see the *Records of the Victoria Archaeological Survey* and particularly Number 3, a guide to recording techniques written by Coutts & Witter (1977). There is also a *Technical Series* with short papers on seed flotation and photography for examples.

## Tasmania

The last piece of legislation to be considered is also one of the latest to have been enacted. Tasmania's *Aboriginal Relics Act 1975* was drawn up during 1975 and, because of this, was able to draw upon the experience of legislation of the other states. The act has the aim of preserving Aboriginal relics and sites and aims to do so by a series of provisions allowing the establishment of an advisory council, declaration of and management of protected sites, vesting certain relics in the Crown and authorisation of wardens and honorary wardens.

Prior to this act, the only legislation impinging on the areas of concern to archaeologists was the *National Parks and Wildlife Act 1970*. The 1970 act was limited in its scope with regard to sites and relics. It lacked, for example, particular provision for a specialist advisory committee and honorary inspectors and/or wardens; sites and portable artefacts were not deemed the property of the Crown or its responsibility in other than particular contexts; researchers or others were not required to report discoveries of relics; the National Parks and Wildlife Service as the sole authority (albeit in limited contexts also) was not required to keep registers, to initiate archaeological research or monitor research or to educate the public about matters relating to site and relic preservation. Nevertheless, certain of its provisions remain basic to the new act and these will be noted where appropriate; the new act complements rather than supplants the old one.

*Aboriginal Relics Act 1975*

The new act defines a relic as:

(a) any artefact, painting, carving, engraving, arrangement of stones, midden, or other object made or created by any of the original inhabitants of Australia or the descendants of any such inhabitant;

(b) any object, site, or place that bears signs of the activities of any such original inhabitants or their descendants; or

(c) the remains of the body of such an original inhabitant or of a descendant of such an inhabitant who died before the year 1876 that are not interred in—

 (i) any land that is or has been held, set aside, reserved, or used for the purposes of a burial ground or cemetery pursuant to any Act, deed, or other instrument; or

 (ii) a marked grave in any other land.

This definition is subject to the provisions of Section 2 which define, *inter alia* that 'No object made or created after 1876 . . . shall be treated as a relic' (Section 2(4)).

The act established an Aboriginal and Relics Advisory Council to recommend on appropriate matters to the Minister and the Director of the National Parks and Wildlife Service, who is responsible for implementation of the act. The Council is to be an expert body comprising the directors of the major Tasmanian museums and three other members appointed by the Governor, among whom shall be included (*a*) someone nominated by the Council of the University of Tasmania and (*b*) two others nominated by the Minister, one of whom is to be 'selected from a list submitted by a body which, in the opinion of the Minister, represents people of Aboriginal descent' (Section 4(1)).

Upon the recommendations of the Director, the Minister may, by order, declare to be a 'protected site' any land containing a relic in order to protect that relic; such an order may, similarly, be revoked at any time; it cannot be made of an area of land which is not Crown Land unless the owner and occupier give their consent in writing; a relic protected in this way is then defined as a 'protected object' (Section 7).

It is then the responsibility of the Director (under Section 8) to manage that site and to protect and preserve its protected objects by carrying out any necessary work including funding, erecting notices, providing facilities, and repairing and restoring objects. In some circumstances, an object may be removed from a protected site and be placed in safe custody if it is thought likely to suffer damage.

With regard to protected sites, the Director's powers are wide. Section 9 provides that:

(1) Except in accordance with the terms of a permit granted by the Director, no person—

 (a) shall destroy, damage, disfigure, conceal, uncover, expose, excavate, or otherwise interfere with a protected object;

 (b) shall carry out an act likely to endanger a protected object; or

 (c) shall destroy, damage, or deface, or otherwise interfere with any fencing or notice erected, or any other work carried out, in or in respect of a protected site in pursuance of this Act.

(2) Except in accordance with the terms of a permit granted by the Minister on the recommendation of the Director, no person shall remove a protected object from a protected site.

(3) Where an authorised officer has reasonable grounds for believing that a protected object has been removed from a protected site contrary to subsection (2), he may seize that object.

Nevertheless, according to a provision of the previous section, the Director may, after informing the Minister, 'cause examinations to be made of the site, whether by way of the carrying out of excavations or other works or otherwise' (Section 8(8)). Anyone so authorised may,

during the day, enter upon the defined land with any necessary equipment to carry out such work and a landowner may be compensated for loss or injury or decrease in value of land resulting from such work (Section 8(11 ff.)).

Another major part of the act deals with 'relics' as opposed to sites. Within six months of the commencement of the act, anyone owning or having knowledge of a relic had to inform the Director. More generally, anyone finding a relic must inform the Director as soon as practicable (Section 10(3)). A portable artefact which, after the time of the commencement of the act, was found on Crown Land is the property of the Crown (Section 11).

Upon the recommendation of the Director and under certain conditions, the Minister may acquire relics on behalf of the Crown. He may, indeed, 'serve notice on the owner of the relic informing him that the relic is required by the Crown and requiring him to deliver the relic to the place specified in the notice, and on the relic being so delivered it vests in and becomes the property of the Crown' (Section 12(2 ff.)). The previous owner may be compensated (Section 12(4 and 5)) and might have the relic returned to him (Section 13(4)).

The Director may then 'cause to be made such scientific or other investigation of the relic as, having regard to the recommendations made by the Council with respect to those investigations, he considers necessary or desirable' (Section 13(1)).

As with sites, the Minister has wide powers with respect to relics; no one shall, except in accordance with his permission:

(a) destroy, damage, deface, conceal, or otherwise interfere with a relic;
(b) make a copy or replica of a carving or engraving that is a relic by rubbing, tracing, casting, or other means that involve direct contact with the carving or engraving;
(c) remove a relic from the place where it is found or abandoned;
(d) sell or offer or expose for sale, exchange, or otherwise dispose of a relic or any other object that so nearly resembles a relic as to be likely to deceive or be capable of being mistaken for a relic;
(e) take a relic, or cause or permit a relic to be taken, out of this State; or
(f) cause an excavation to be made or any other work to be carried out on Crown Land for the purpose of searching for a relic. [Section 14(1)]

Where an offence in relation to a relic has been, or appears about to be committed, a relic may be seized (Section 14(4)), and upon conviction a relic may be forfeited to the Crown (Section 14(5)).

In order to enforce these provisions, the Director may appoint officers of the National Parks and Wildlife Service or, with the Minister's approval, other persons to be wardens or honorary wardens under the act. Wardens act under the supervision of the Director and they, and honorary wardens, may have their powers restricted to a particular site (Sections 15 and 16).

A warden or honorary warden may require a person suspected of committing an offence to give his name and address and to leave a protected site and it is an offence not to do so (Section 17). Under some circumstances a warden's powers may be considerably extended (Section 18).

Regulations may be made for the purposes of the act, especially for the 'care, control and management of protected sites' and protected objects; they may provide for the conduct of persons in protected sites and impose penalties (Section 25).

*National Parks and Wildlife Act 1970*

Under the 1970 act, the Director, who is responsible to the Minister for its administration, has a range of responsibilities which relate directly to the management of sites and relics, although these are differently defined (Section 3(1)). Potentially important among these is the matter of reviewing the reservation of land and its use and promoting '. . . research and other activities that appear to him desirable in connection with the administration of this Act . . .' (Section 6).

The main relevance of the act resides in its ability to reserve and acquire land for conservation purposes, including the protection of archaeological features and Aboriginal relics (Section 13(d) and (e)). But while land may be declared to be a conservation area, this requires the consent of the owner for private land; such conservation areas can be varied or abolished by the Governor (Sections 14 and 16). A plan for the management of reserved areas may restrict access (Section 25) and there can be made regulations which presumably could permit archaeological research in such areas (Section 28).

*Summary*

The Tasmanian National Parks and Wildlife Service now has a Service Archaeologist to assist in the implementation of both acts. It is clear from the later legislation that Tasmania now has a relatively comprehensive act to protect archaeological materials and to control dealing in relics. Many of its provisions relating to sites apply, however, only to land reserved and under the control of the National Parks and Wildlife Service and it is not yet apparent how willing the Director and Minister will be with relation to the implementation of these provisions, or how effective those dealing especially with 'relics' will be in protecting archaeological deposits and in controlling survey and excavation.

There appears to be little published material concerning the acts and their implementation; a note by Stockton (1977) concerning the new legislation offers a short summary and an attempt to assuage fears concerning its provisions.

## CONCLUSION

This chapter has set out to review the legislation pertaining to archaeological sites and their investigation in Australian states and territories. Because of the diversity of legislation—in basic stance and assumptions as well as detail—it has been difficult to accomplish concisely, and although the information it contains should be found to be accurate as at the beginning of 1981 it should not be considered to be a substitute for a detailed reading of the relevant acts themselves by anyone contemplating a research project. Any attempt at an even shorter summary at this point would probably be more misleading than informative; it should suffice to say in concluding the review that nearly all parts of the country have legislation that impinges upon the activities of archaeologists whether they are involved in systematic surveys, surface collecting or actual excavation; it is contingent upon them, therefore, to make themselves familiar with the legislations and their regulations before commencing fieldwork. The discussions presented above will offer a guide to the reading of the acts; the caveat that the reader must be aware of the likelihood of more recent revisions and amendments of the various acts and regulations than those anticipated here gains strength the greater the period since the time of writing.

As well as a consideration of the responsibilities of the researcher under the legislation, this review has prompted several observations about the scope and adequacy of the acts themselves in fulfilling their stated intentions and those objectives to which they might be expected to be applied. All acts are inadequate in some

respects, some more inadequate than others. Most could do with considerable revision to achieve more fully the basic objects of preserving the country's cultural heritage in balance with other interests and allowing its responsible and systematic study.

One of the first impressions the reviewer receives is the extent of duplication, repetition and reiteration of the provisions of the legislation as one moves from state to state. Given that the aims of the various legislations are basically similar, there is much duplication of effort in arriving at sets of basically similar conclusions. The process clearly has been wasteful of resources and, given the number of acts recently having been, currently being, and intended to be, revised or amended, the results unsatisfactory. Beyond this, the process is inefficient in another aspect—the archaeological researcher must expend extra effort in comprehending the extra legislative provisions and their implementation if he is to contemplate work in more than one state or territory. From an archaeologist's perspective, a greater degree of uniformity among the various state acts would contribute toward a readier appreciation of their aims and procedures. This is not necessarily to argue that an overriding federal act would be preferable—if possible—but that greater cooperation among those responsible for the legislation in each state is desirable. (One area in which it is not only desirable but necessary—in default of federal legislation—is the difficult and as yet unresolved matter of adequate restriction of the trade in artefacts between states.)

This lack of uniformity is not a trivial matter; each state act impinges heavily upon the researcher, restricting his activities as much, if not more so in some cases, than it does other sections of the public. (The fact that several provisions of some acts are more restrictive of *bona fide* researchers than someone engaging in the same type of activity which is not explicitly research-oriented—or at least 'searching for relics'—gives them a Nero-like quality.) Anyway, there is irony, given the size of the archaeological community in Australia, in the collective weight of the legislation imposing upon it.

Another aspect of many of the state acts that archaeologists would deplore is the lack of consideration given in many of them to Aboriginal interest in areas of earlier occupation which might reflect traditional usage by the manifestation of identifiable 'relics'. Nevertheless, the researcher should not take this lack of concern of the White legislator to suggest that he should not identify and take into consideration Black interests when planning and implementing his research; most state authorities require such consideration to be made and, beyond this, it is a basic courtesy. Those few not interested in courtesy might well consider the matter's implications for their own short and long term self-interest. Ultimately, any revision of an act providing explicit guidelines to the researcher on how to proceed in this area will benefit all concerned.

One of the major sources of inadequacy common to several of the acts considered here is their lack of ability to protect and manage all occurrences of sites anywhere in the state. Some provisions of each act relate only to reserved land—'prohibited' and 'protected' areas—others cover only Crown Land and, in the majority of cases, provide for sites on 'private' land *only with the consent of the owner and/or occupier*. This might be seen as the source of most of the significant failures of many of the legislative provisions.

It would be hoped that any revisions to the current legislations would include adequate teeth with which to provide for the correction of the ignorant and avaricious in any community whose actions lead to the destruction or despoilation of archaeological evidence. The example quoted as having until recently been an integral part of the Western Australian legislation would be a suitable paradigm if authorities considered themselves able to make use of it. Few, it would appear, do think that they are able to seek the penalties provided for by their acts. In some cases, it seems that their evaluation of the situation suggests that it would be counter-productive in terms of public opinion; in others, it would appear, the state attorney's advice is that these provisions are unworkable. The most common reason for this is the escape clause which says something like 'it is not an offence (to commit an antisocial act) if the person did not know that its subject was an Aboriginal relic'—an explicit reversal of the usual provision of legislation which provides that 'ignorance is no excuse'.

But this area concerns the general public; the researcher will be aware of what constitutes a 'relic' and act accordingly. There are few aspects of the various acts that do not effectively limit the activities of the researcher, whether amateur or professional. It is another irony of the legislations that they tend to deal most effectively with those that are least likely to offend against them and affect least those individuals or institutions which are most likely to transgress against their provisions for protection and effective management of resources. It is difficult to suggest in the present context how adequately balanced legislation might be accomplished but one important provision surely would be to ensure that the implementation of the legislation was free from political interference. In a society whose spokesmen are wont to refer to the processes of 'checks and balances' in maintaining an acceptable equilibrium of its multifaceted interests, there is some excuse for the wry observation of some that the most frequent contribution of some of our politicians is to remove anything checking their own interest.

More positively, while few state instrumentalities are explicitly charged with the responsibility for education of the public in the area of appreciation of the value of the cultural resources in their care and the necessity for the management provisions which they attempt to implement, most are to some degree involved in public education. It could well be seen as a considerable investment for the future of our society as well as our archaeological resources that more emphasis should be given to this aspect. Archaeologists might consider the value of persuading the public purse to relinquish more resources for this purpose as well as responsibly observing themselves the requirements of the various legislations.

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## APPENDIX 1

This appendix details the titles and numbers of the various state acts, dates of and revisions and/or amendments, the addresses of departments from which copies might be obtained, and the title and address of those responsible for day-to-day implementation of the legislation and its regulations from whom intending researchers should seek any clarification required and permissions where necessary before commencing their field studies. Acts marked by an asterisk (*) were reprinted in Edwards (1975).

### Western Australia

*Aboriginal Heritage Act 1972* (Number 53 of 1972)*

*Aboriginal Heritage Amendment Act (Number 2) 1980* (Number 8 to 1980)

Copies from

Government Printer
Station Street, Wembley, WA 6014.

Implementation by

The Registrar of Aboriginal Sites
Department of Aboriginal Sites
Western Australian Museum
Francis Street, Perth, WA 6000.

### Northern Territory

*Native and Historical Objects and Areas Preservation Ordinance 1955–1960* (Number 11, 1961)*

*Native and Historical Objects Preservation Ordinance 1955* (Regulations 1957, Number 14)

Copies from

Chief Minister
Office of the Chief Minister
PO Box 4396, Darwin, NT 5794.

Implementation by

The Director
Museums and Art Galleries of the Northern Territory
PO Box 4646, Darwin, NT 5794.

*Aboriginal Sacred Sites Act 1978* (Number 115 of 1978)

*Aboriginal Sacred Sites Act (Number 2) 1978* (Number 116 of 1978)

Copies from

Government Printer of the Northern Territory
Mitchell Street, Darwin, NT 5790.

Implementation by

The Director
The Aboriginal Sacred Sites Protection Authority
PO Box 1890, Darwin, NT 5794.

### South Australia

*Aboriginal and Historic Relics Preservation Act, 1965* (Number 33 of 1965).*

*Aboriginal Heritage Act, 1979* (Number 46 of 1979)

Copies from

Government Printer
282 West Beach Road, Netley, SA 5037.

Implemented by

Head, Aboriginal Heritage Section
Heritage Conservation Branch
Department of the Environment and Planning
GPO, Box 677, Adelaide, SA 5001.

### Queensland

*Aboriginal Relics Preservation Act of 1967* (Number 29 of 1967)*

*Aboriginal Relics Preservation Act Amendment Act 1976* (Number 3 of 1976)

Copies from

Government Printer
102-106 George Street
Brisbane, Qld 4000.

Implemented by

Officer-in-Charge, Archaeology Branch
Department of Aboriginal and Islanders Advancement
PO Box 2210
Brisbane, Qld 4000.

### New South Wales

*National Parks and Wildlife Act, 1974* (Act Number 80, 1974)*

Copies from

Government Printer
390 Harris Street
Ultimo, NSW 2007.

Implemented by

Director
*via* Chief, Aboriginal and Historic Resources Section
New South Wales National Parks and Wildlife Service
189 Kent Street
Sydney, NSW 2000

### Australian Capital Territory

No legislation now in force; a proposed ordinance covers only reserved areas.

*The Nature Conservation Ordinance* (Number 20 of 1980)

Copies from

Commonwealth Government Printer
Wentworth Avenue
Kingston, ACT 2604.

Implemented by

The Conservator of Wildlife
Conservation and Agriculture Section
Department of the Capital Territory
South Building
Canberra City, ACT 2600.

### Victoria

*The Archaeological and Aboriginal Relics Preservation Act* (1972, Number 8273)*

*Archaeological and Aboriginal Relics Preservation (Amendment) Act 1980* (Number 9405)

Copies from

Government Printer
2a Parliament Place
Melbourne, Vic. 3000.

Implemented by

The Director
Victoria Archaeological Survey
Ministry for Conservation
29–31 Victoria Avenue
Albert Park, Vic. 3206.

### Tasmania

*Aboriginal Relics Act 1975* (Number 81 of 1975)

*National Parks and Wildlife Act 1970* (Number 47 of 1970).*

Copies from

Government Printer
Salamanca Place
Hobart, Tas. 7000.

Implemented by

Director,
*via* Service Archaeologist
Tasmanian National Parks and Wildlife Service
PO Box 210
Sandy Bay, Tas. 7005.

## APPENDIX 2

*Table 1*

### WESTERN AUSTRALIA*

| | |
|---|---|
| **Administration of the current legislation** | |
| Date | 1972–1980 |
| Assented to | October 1972 |
| Came into operation | December 1972 |
| Revised/amended | 1980 |
| Assented to | September 1980 |
| Came into operation | September 1980 |
| Administration by | Minister; S10 |
| Advisory committee | Aboriginal Cultural Material Committee; S28 |
| Appointed | by Minister; S28 |
| Composition: | appointed and three *ex officio* |
| university/museum | Director of Museum; S29 |
| Lands Department | Surveyor General; S29 |
| Aboriginal interest | person responsible to Minister for Aboriginal Affairs and one expert; S29, S28 |
| Implementation by | Registrar of Aboriginal Sites, WA Museum; S10 |
| Local inspectors/wardens | Wardens; S50 |
| Aboriginal involvement | traditional custodians; S9 |
| Aboriginal rights of access to reserved areas | yes; S7 |
| **Research, recording** | |
| Official register of sites | yes; S38 |
| State responsible for evaluation of sites | yes; S10, S39 |
| Site finds to be reported | yes; S15 |
| Official register of artefacts | yes; S38 |
| Artefact finds to be reported | yes; S15 |
| State responsible for initiating research | yes; S10, S39 |
| Education of public | not specified |
| **Site protection and management** | |
| All sites state property | yes; S5, S14 |
| State responsible for site protection | yes; S39 |
| Crown Lands can be reserved | yes; Ss18-22 |
| Sites can be declared: | |
| (*a*) prohibited areas | yes; S22 |
| (*b*) protected areas | yes; Ss18-20 |
| Declared sites to be gazetted | yes; S19 'Order in Council' |
| Declared sites to be signposted | optional; S23 |
| Provision for purchase by authority | yes; S22 |
| Provision for compulsory state acquisition | yes; S22(3) |
| Compensation available to landholder | yes; S22(2) |
| Entry may be restricted | yes; S22, S26 |
| Destruction, etc., prohibited | yes; S22, S26 |
| **Artefact protection and management** | |
| Basic state ownership | yes; S6, S14, S46 |
| Private ownership permitted | yes; S46 |
| Trading prohibited | yes; S43 |
| Export restricted | yes; S43 |
| Export prohibited | i.e., except for certain exchanges |
| Provision for purchase by authority | yes; S43(2) |
| Provision for compulsory state acquisition | yes; S47 |
| Compensation available to finder | yes; S43(2) |
| **Permission for archaeological survey/excavation** | |
| Permit required for survey | no |
| All excavation by state permit only | yes; S16, S17 |
| Permit required only for Crown land | no |
| Permit required only for reserved land | no |
| Permission of landholder required | not specified |
| **Salvage of threatened sites** | |
| Threatened sites to be reported | yes; S18(2) |
| Developer to consult state authority | yes; S18(2) |
| State agencies responsible: | |
| (*a*) for examination of sites | yes; S18(2) |
| (*b*) for effecting salvage | yes; S18(5) |
| (*c*) for meeting cost of salvage | not specified |
| Developer responsible: | |
| (*a*) for examination of site | yes; S18(2) |
| (*b*) for providing time for salvage | yes; S18(2) |
| (*c*) for meeting cost of salvage | not specified; but see S18(2) |
| **Reports of research** | |
| Preliminary report required within months | not specified; but see Ss16, 18 |
| Final report required within two years | not specified; but see Ss16, 18 |
| **Penalties provided for offences** | S57 (up to $2000 plus $100 per day and imprisonment for 12 months) |

* The *Aboriginal Heritage Act 1972–1980* (No. 53 of 1972; No. 8 of 1980)

*Table 2*

## NORTHERN TERRITORY (1)*

### Administration of the current legislation

| | |
|---|---|
| Date | 1955–1961 |
| Assented to | August 1955 |
| Came into operation | August 1957 |
| Revised/amended | 1960, 1961 |
| Assented to | February 1961 |
| Came into operation | February 1961 |
| Administration by | The Administrator of the Northern Territory |
| Advisory committee | none specified |
| Implementation by | Administrator through Museums and Art Galleries of the Northern Territory |
| Local inspectors/wardens | Rangers; S9 |
| Aboriginal involvement | not specified |
| Aboriginal rights of access to reserved areas | not specified |

### Research, recording

| | |
|---|---|
| Official register of sites | not specified |
| State responsible for evaluation of sites | no |
| Site finds to be reported | upon request; S9 |
| Official register of artefacts | not specified |
| Artefact finds to be reported | upon request; S9 |
| State responsible for initiating research | not specified |
| Education of public | not specified |

### Site protection and management

| | |
|---|---|
| All sites state property | no |
| State responsible for site protection | no |
| Crown Lands can be reserved | yes; S9A |
| Sites can be declared: | |
| (*a*) prohibited areas | only on Crown Land; S9A |
| (*b*) protected areas | no |
| Declared sites to be gazetted | yes; S9A |
| Declared sites to be signposted | no |
| Provision for purchase by authority | no |
| Provision for compulsory state acquisition | no |
| Compensation available to landholder | no |
| Entry may be restricted | yes; S9G |
| Destruction, etc., prohibited | yes; S9H |

### Artefact protection and management

| | |
|---|---|
| Basic state ownership | no; but see S7 |
| Private ownership permitted | yes |
| Trading restricted | yes; S7 |
| Trading prohibited | no |
| Export restricted | yes; S7 |
| Export prohibited | no |
| Provision for purchase by authority | yes; S7(3) |
| Provision for compulsory state acquisition | yes; Ss6, 7 |
| Compensation available to finder | yes; Ss6, 7 |

### Permission for archaeological survey/excavation

| | |
|---|---|
| Permit required for survey | no; but see S9H |
| All excavation by state permit only | yes; S9H |
| Permission of landholder required | no |

### Salvage of threatened sites

| | |
|---|---|
| Threatened sites to be reported | yes; S9H |
| Developer to consult state authority | implied by S9H |
| State agencies responsible | no |
| Developer responsible | no |

### Reports of research

| | |
|---|---|
| Preliminary report required within months | no |
| Final report required within two years | no |

| | |
|---|---|
| **Penalties provided for offences** | S10; (100 pounds or up to 3 months' imprisonment) |

* The *Native and Historical Objects and Areas Preservation Ordinance 1955–1960* (No. 15, 1955; No. 20, 1961; No. 11, 1961).

*Table 3*

NORTHERN TERRITORY (2)*

| | |
|---|---|
| **Administration of the current legislation** | |
| Date | 1978–1979 |
| Assented to | September 1979 |
| Came into operation | September 1979 |
| Revised/amended | 1978 |
| Assented to | September 1979 |
| Came into operation | September 1979 |
| Administration by | Administrator, NT Government |
| Advisory committee | yes—twelve members; S4 |
| Appointed | by Administrator; S5 |
| Composition: | eleven appointed: |
| university/museum | possible and Director of Museum *ex officio* S5 |
| Lands Department | possible |
| Aboriginal interest | yes—at least seven Aborigines; S5 |
| Implementation by | Aboriginal Sacred Sites Protection Authority |
| Local inspectors/wardens | yes; S30 |
| Aboriginal involvement | yes; S5 *et seq.* |
| Aboriginal rights of access to reserved areas | yes; S31A |
| **Research, recording** | |
| Official register of sites | yes; S24 |
| State responsible for evaluation of sites | yes; Ss25–26 |
| Site finds to be reported | no |
| Official register of artefacts | no |
| Artefact finds to be reported | no |
| State responsible for initiating research | no |
| Education of public | no |
| **Site protection and management** | |
| All sites state property | no (but major part of act applies only to registered and declared areas) |
| State responsible for site protection | yes; for reserved areas; Ss27–28 |
| Crown lands can be reserved | yes; S28(b) |
| Sites can be declared: | |
| (*a*) prohibited areas | i.e., 'sacred sites'; S28(1) |
| (*b*) protected areas | yes; S27 |
| Declared sites to be gazetted | yes; S28(1) |
| Declared sites to be signposted | may be; S28(1) |
| Provision for purchase by authority | yes; S28(1) |
| Provision for compulsory state acquisition | yes; S28 |
| Compensation available to landholder | yes; S28 |
| Entry may be restricted | yes; S31(3 and 4) |
| Destruction, etc., prohibited | implied; S29(2), S31(4) |
| **Artefact protection and management** | is not affected |
| **Permission for archaeological survey/excavation** | |
| Permit required for survey | no |
| All excavation by state permit only | no |
| Permit required only for Crown land | no |
| Permit required only for reserved land | yes; Ss29(2) and Ss31(4) |
| Permission of landholder required | not specified |
| **Salvage of threatened sites** | is not affected |
| **Reports of research** | |
| Preliminary report required within months | no |
| Final report required within two years | no |
| **Penalties provided for offences** | S31; (up to $2000 and imprisonment for 12 months) |

* The *Aboriginal Sacred Sites Act 1978* (No. 115 of 1978); the *Aboriginal Sacred Sites Amendment Act* (No. 116 of 1978).

*Table 4*

## SOUTH AUSTRALIA (1)*

### Administration of the current legislation

| | |
|---|---|
| Date | 1965 |
| Assented to | 9 December 1965 |
| Came into operation | 3 August 1967 |
| Administration by | Minister; S5 |
| Advisory committee | yes; S6 |
| Appointed | by Minister |
| Composition: | S6 |
| university/museum | both |
| Lands Department | yes |
| Aboriginal interest | State's Department of Aboriginal Affairs |
| Implementation by | 'A Protector of Relics' originally the Director of the SA Museum later permanent head of the Department for the Environment |
| Local inspectors/wardens | both; S9 |
| Aboriginal involvement | not specified |
| Aboriginal rights of access to reserved areas | yes; S4(1) |

### Research, recording

| | |
|---|---|
| Official register of sites | yes; S10(1) |
| State responsible for evaluation of sites | no |
| Site finds to be reported | yes, if a site is a 'relic' |
| Official register of artefacts | no |
| Artefact finds to be reported | yes; S28(2) (cf. European relics S21(2)) |
| State responsible for initiating research | yes; S10(2) |
| Education of public | no |

### Site protection and management

| | |
|---|---|
| 'Sites' adequately defined | no; only as 'relic'; S3(1) |
| All sites state property | no |
| State responsible for site protection | of 'Prohibited Areas' and 'Historic Reserves'; Ss16, 17, 21 to 28. Also undeclared sites; Ss10, 28 |
| Crown lands can be reserved | yes; Ss16 to 18 |
| Sites can be declared: | |
| (*a*) prohibited areas | yes; S16, but only with consent of Minister or private landholder; S18 |
| (*b*) protected areas | yes; S17, with similar consents |
| Declared sites to be gazetted | yes; Ss16 and 17 |
| Declared sites to be signposted | may be; S20(1) |
| Provision for purchase by authority | yes; S26 |
| Provision for compulsory state acquisition | yes; S19(1) |
| Compensation available to landholder | yes; S25 |
| Entry may be restricted | yes; S22 |
| Destruction, etc., prohibited | yes; Ss23 and 28 |

### Artefact protection and management

| | |
|---|---|
| Basic state ownership | no, only those within Protected Areas or Historic Reserves; S21(1) (cf. early European relics, S21(2)) |
| Private ownership permitted | yes, and collecting; S27(1) |
| Trading prohibited | yes; S27(2) |
| Export restricted | no |
| Export prohibited | no |
| Provision for purchase by authority | yes; S26(a) |
| Provision for compulsory state acquisition | yes; ?S21(2), S26(a) |
| Compensation available to finder | possibly, if landholder; S25(1) |

### Permission for archaeological survey/excavation

| | |
|---|---|
| Permit required for survey | no |
| All excavation by state permit only | no; except on Prohibited Areas and Historic Reserves; S28(1) |
| Permit required only for Crown land | no; except on PAs and HRs; S22(2a) |
| Permit required only for reserved land | yes; Ss22, 23 and 24(1) |
| Permission of landholder required | possibly, but only if Prohibited Area on private land; S22(2b). |

### Salvage of threatened sites

| | |
|---|---|
| Threatened sites to be reported | not especially |
| Developer to consult state authority | no |
| State agencies responsible | no |
| Developer responsible | no |

### Reports of research

| | |
|---|---|
| Preliminary report required within months | no |
| Final report required within two years | no |

| | |
|---|---|
| **Penalties provided for offences** | S29; (fine of up to $200 or imprisonment for up to 3 months) |

* The *Aboriginal and Historic Relics Preservation Act, 1965* (No. 33 of 1965)

*Table 5*

## SOUTH AUSTRALIA (2)*

| | |
|---|---|
| **Administration of the current legislation** | |
| Date | 1979 |
| Assented to | 15 March 1979 |
| Came into operation | not yet proclaimed |
| Administration by | Minister; S7 |
| Advisory committee | 'Aboriginal Heritage Committee'; S11(1) |
| Appointed | by Governor; S11(2) |
| Composition: | nine members; S11(2) |
| university/museum | nominee of Board of SA Museum; S11(2b) |
| Lands Department | nominee of the Pastoral Board; S11(2c) |
| Aboriginal interest | at least three Aborigines; S11(2a) |
| Implementation by | Senior Heritage Officer, Heritage Unit |
| Local inspectors/wardens | Inspectors, no wardens; S18 |
| Aboriginal involvement | as members of AHC, Inspectors; Ss11, 18 |
| Aboriginal rights of access to reserved areas | yes; S6 |
| **Research, recording** | |
| Official register of sites | yes; S7(1b) |
| State responsible for evaluation of sites | not explicitly |
| Site finds to be reported | yes; S28 |
| Official register of artefacts | yes; S7(1b) |
| Artefact finds to be reported | yes; S28 |
| State responsible for initiating research | yes; S7(1a) |
| Education of public | no |
| **Site protection and management** | |
| All sites state property | no |
| State responsible for site protection | yes; S7(1e), Ss21 ff. |
| Crown lands can be reserved | by implication; S21(1) |
| Sites can be declared: | |
| (*a*) prohibited areas | yes; S21 |
| (*b*) protected areas | yes; S21 |
| Declared sites to be gazetted | yes; S21(1) |
| Declared sites to be signposted | may be; S22 |
| Provision for purchase by authority | yes; S24 |
| Provision for compulsory state acquisition | yes; S24 |
| Compensation available to landholder | no |
| Entry may be restricted | yes; S21(5) |
| Destruction, etc., prohibited | can be; S25(1) |
| **Artefact protection and management** | |
| Basic state ownership | no |
| Private ownership permitted | yes; S25(3 and 4) |
| Trading restricted | yes; S25(5) |
| Trading prohibited | no |
| Export restricted | no |
| Export prohibited | no |
| Provision for purchase by authority | yes; S9(a) |
| Provision for compulsory state acquisition | no |
| Compensation available to finder | no |
| **Permission for archaeological survey/excavation** | |
| Permit required for survey | no; but see S25(2–4) |
| All excavation by state permit only | yes; S25(1) |
| Permission of landholder required | no; but see S26(2 and 3) |
| **Salvage of threatened sites** | |
| Threatened sites to be reported | no |
| Developer to consult state authority | no |
| State agencies responsible: | |
| (*a*) for examination of sites | no; but see S26(1) |
| (*b*) for effecting salvage | no |
| (*c*) for meeting cost of salvage | no; but see S26(4) |
| Developer responsible: | |
| (*a*) for examination of site | no |
| (*b*) for providing time for salvage | no |
| (*c*) for meeting cost of salvage | no |
| **Reports of research** | |
| Preliminary report required within months | no |
| Final report required within two years | no |
| **Penalties provided for offences** | As in various sections (e.g.: S27(1), penalty for damaging or destroying a registered item is $10 000 or imprisonment for 3 months) |

* The *Aboriginal Heritage Act, 1979* (No. 46 of 1979).

*Table 6*

## QUEENSLAND*

### Administration of the current legislation

| | |
|---|---|
| Date | 1967–76 |
| Assented to | 3 November 1967 |
| Came into operation | May 1968 |
| Revised/amended | 1976 |
| Assented to | 29 March 1976 |
| Came into operation | March 1976 |
| Administration by | Minister; S5 |
| Advisory committee | yes; Ss9 to 12 |
| Appointed by | Governor in Council; S9 |
| Composition: | |
| university/museum | both; S9 |
| Lands Department | not specified |
| Aboriginal interest | not specified (in practice, two Aboriginal members) |
| Implementation by | Archaeology Branch, DAIA |
| Local inspectors/wardens | both; S6 |
| Aboriginal involvement | not specified |
| Aboriginal rights of access to reserved areas | not specified but tribal rites 'not affected'; S4 |

### Research, recording

| | |
|---|---|
| Official register of sites | not specified |
| State responsible for evaluation of sites | yes; S12 |
| Site finds to be reported | some; S23 |
| Official register of artefacts | no (see *Museums Act* of 1970–1979) |
| Artefact finds to be reported | by authorized researcher; Ss22, 23 |
| State responsible for initiating research | not specified |
| Education of public | not specified |

### Site protection and management

| | |
|---|---|
| All sites state property | yes, if 'relic' in the Act's terms |
| State responsible for site protection | only of declared sites; S20 |
| Crown lands can be reserved | yes; S13, but also S14 |
| Sites can be declared: | |
| (*a*) prohibited areas | yes; S12 |
| (*b*) protected areas | no |
| Declared sites to be gazetted | yes; S13 'Order in Council' |
| Declared sites to be signposted | may be; S17 |
| Provision for purchase by authority | yes; S16 |
| Provision for compulsory state acquisition | yes; S16 |
| Compensation available to landholder | yes; if private land and if resumed (Ss16, 26) through land court (*Lands Act 1962–1980*) |
| Entry may be restricted | yes; S19 |
| Destruction, etc., prohibited | yes; S20 |

### Artefact protection and management

| | |
|---|---|
| Basic state ownership | yes; S18 |
| Private ownership permitted | yes; S18 |
| Trading restricted | no |
| Export restricted | only if obtained by authorized research; S22(2) |
| Provision for purchase by authority | yes; S24 |
| Provision for compulsory state acquisition | yes; S24(a) |
| Compensation available to finder | no, because 'relics' are Crown property |

### Permission for archaeological survey/excavation

| | |
|---|---|
| Permit required for survey | yes; S21(2) |
| All excavation by state permit only | yes; S21(2) |
| Permission of landholder required | yes; private land; S21(3b) |

### Salvage of threatened sites

| | |
|---|---|
| Threatened sites to be reported | no |
| Developer to consult state authority | no (but see *Environment Act*) |
| State agencies responsible | no |
| Developer responsible | not specified but onus is on individual not to disturb; S20 |

### Reports of research

| | |
|---|---|
| Preliminary report required within months | no |
| Final report required within two years | no, but see S21(6) |

| | |
|---|---|
| **Penalties provided for offences** | see amendment act, 1976, S8: (fine of up to $500 and imprisonment for 6 months) |

* The *Aboriginal Relics Preservation Act* of 1967–1976 (No. 29 of 1967 and No. 3 of 1976).

*Table 7*

## NEW SOUTH WALES*

| | |
|---|---|
| **Administration of the current legislation** | |
| Date | 1967–1974 |
| Assented to | 1 September 1967 |
| Came into operation | 1 October 1967 |
| Revised/amended | 1974 |
| Assented to | 27 November 1974 |
| Came into operation | 1 January 1975 |
| Administration by | Minister; S8 |
| Advisory committee | yes; S27 |
| Appointed | by Minister, Schedule 9 |
| Composition: university/museum, Lands Department, Aboriginal interest | (see text for recent changes) |
| Implementation by | Aboriginal and Historic Resources Section, NSW NPWS |
| Local inspectors/wardens | rangers and honorary rangers; S17 |
| Aboriginal involvement | not specified (but see text) |
| Aboriginal rights of access to reserved areas | not specified |
| **Research, recording** | |
| Official register of sites | not specified |
| State responsible for evaluation of sites | yes; S8 (1 and 2) |
| Site finds to be reported | yes; S91 |
| Official register of artefacts | no |
| Artefact finds to be reported | yes; S91 |
| State responsible for initiating research | yes; S8(4) |
| Education of public | for particular areas; S8(3) Honorary Rangers, etc.; S8(8) |
| **Site protection and management** | |
| All sites state property | yes; if not real property; S83(1) |
| State responsible for site protection | yes; Ss12, 85 |
| Crown lands can be reserved | yes; Ss62 to 66 |
| Sites can be declared: | |
| (*a*) prohibited areas | yes; Ss65 to 66 |
| (*b*) protected areas | yes; Ss65 to 66 |
| Declared sites to be gazetted | may be; S84 |
| Declared sites to be signposted | may be; Ss114 to 156 |
| Provision for purchase by authority | yes; Ss89, 139 |
| Provision for compulsory state acquisition | yes; Minister has general powers |
| Compensation available to landholder | yes; in cases of resumption |
| Entry may be restricted | yes; S66 |
| Destruction, etc., prohibited | yes; S86, 90 |
| **Artefact protection and management** | |
| Basic state ownership | yes; S83 |
| Private ownership permitted | yes; S83 |
| Trading restricted | yes; for items belonging to Crown; S88 |
| Trading prohibited | no |
| Export restricted | not specifically |
| Provision for purchase by authority | yes; S89 |
| Provision for compulsory state acquisition | no |
| Compensation available to finder | no |
| **Permission for archaeological survey/excavation** | |
| Permit required for survey | no |
| All excavation by state permit only | yes; S87 |
| Permission of landholder required | not specified |
| **Salvage of threatened sites** | |
| Threatened sites to be reported | not specifically but see S86 |
| Developer to consult state authority | yes see *Environmental Planning and Assessment Act 1979 (Regulations 1980)* |
| State agencies responsible: | |
| (*a*) for examination of sites | no |
| (*b*) for effecting salvage | no; but see S85 |
| (*c*) for meeting cost of salvage | no; but see S85 |
| Developer responsible | may be; S90 and EP and A Act |
| **Reports of research** | |
| Preliminary report required within months; Final report required within two years | not specified; but see S87, relating to terms and conditions of permits |
| **Penalties provided for offences** | S90, for destruction of relics or Aboriginal places, provides for fine of $1000 plus $100 for each day offence continues and imprisonment for 6 months |

* The *National Parks and Wildlife Act, 1974* (No. 80 of 1974).

*Table 8*

## VICTORIA*

### Administration of the current legislation

| | |
|---|---|
| Date | 1972 (No. 8273) |
| Assented to | May 1972 |
| Came into operation | August 1972 |
| Revised/amended | amended 1980 (No. 9405) |
| Assented to | May 1980 |
| Came into operation | 6 October 1980 |
| Administration by | Minister; S4 |
| Advisory committee | yes; S5 |
| Appointed | by Governor in Council; S5 |
| Composition: | Director of Conservation and eleven others |
| university/museum | Director of Museum or nominee, a professional archaeologist from a Victorian university |
| Lands Department | Secretary of Lands or his nominee |
| Aboriginal interest | Three members |
| Implementation by | Director of Conservation and Victoria Archaeological Survey |
| Local inspectors/wardens | both; S9 |
| Aboriginal involvement | not specified |
| Aboriginal rights of access to reserved areas | no |

### Research, recording

| | |
|---|---|
| Official register of sites | yes; S10(a) |
| State responsible for evaluation of sites | yes; S22(3) |
| Site finds to be reported | yes; S22(5), S23(1) |
| Official register of artefacts | yes; S10(a) |
| Artefact finds to be reported | yes; Ss22(5), 23(1), 27(2) |
| State responsible for initiating research | yes; S10(b and c) |
| Education of public | yes; S10(e) |

### Site protection and management

| | |
|---|---|
| All sites state property | no (but relics within reserved areas are) |
| State responsible for site protection | yes, implied throughout |
| Crown lands can be reserved | yes; S15 |
| Sites can be declared: | |
| (*a*) prohibited areas | archaeological areas; Ss15, 17 |
| (*b*) protected areas | archaeological areas; S15 |
| Declared sites to be gazetted | yes; S15 |
| Declared sites to be signposted | may be; S19 |
| Provision for purchase by authority | yes; S26(1) |
| Provision for compulsory state acquisition | yes; S18 |
| Compensation available to landholder | yes; S18, S25(2) |
| Entry may be restricted | yes; S17 |
| Destruction, etc., prohibited | of gazetted areas; S15(1b) |

### Artefact protection and management

| | |
|---|---|
| Basic state ownership | no; but see S20 |
| Private ownership permitted | yes; S26 |
| Trading restricted | yes; S26(2 and 3) |
| Trading prohibited | no; S26(3), S27(3) |
| Export restricted | not specified |
| Export prohibited | not specified |
| Provision for purchase by authority | yes; S26(1) |
| Provision for compulsory state acquisition | possible; S25(1) |
| Compensation available to finder | possible; S25(2) |

### Permission for archaeological survey/excavation

| | |
|---|---|
| Permit required for survey | no, but notification required; S22(5) |
| All excavation by state permit only | yes; S22(1) |
| Permission of landholder required | possible; S22 (see also regulations) |

### Salvage of threatened sites

| | |
|---|---|
| Threatened sites to be reported | no |
| Developer to consult state authority | no |
| State agencies responsible: | |
| (*a*) for examination of sites | yes; S22(3) |
| (*b*) for effecting salvage | not explicit, but possible |
| (*c*) for meeting cost of salvage | Ss22, 25 |
| Developer responsible | no, but possible under S22 |

### Reports of research

| | |
|---|---|
| Preliminary report required within months | possible; S22(5) |
| Final report required within two years | possible; S22(5) |

| | |
|---|---|
| **Penalties provided for offences** | S28; see S14 of amendment act (fine of up to $1000 or 3 months' imprisonment or both) |

* The *Archaeological and Aboriginal Relics Preservation Act* (1972–1980) (No. 8273 of 1972 and No. 9405 of 1980).

*Table 9*

**TASMANIA***

| | | |
|---|---|---|
| **Administration of the current legislation** | | |
| Date | 1975 | 1970 |
| Assented to | February 1976 | December 1970 |
| Came into operation | March 1976 | |
| Administration by | Minister; S3 | Minister; S6 |
| Advisory committee | yes; S4 | |
| Appointed | by Governor in Council; S4 | — |
| Composition: university/museum | Directors of both state museums | — |
| Lands Department | no | |
| Aboriginal interest | yes | |
| Implementation by | Tasmanian National Parks and Wildlife Service | |
| Local inspectors/wardens | Wardens: NPWS Officers (S15), Honorary Wardens (S16); | NPWS Rangers; S8 |
| Aboriginal involvement | not specified | not specified |
| Aboriginal rights of access to reserved areas | not specified | no |
| **Research, recording** | | |
| Official register of sites | not specified | not specified |
| State responsible for evaluation of sites | yes; S13 | not specifically |
| Site finds to be reported | yes; S10 | not specifically |
| Official register of artefacts | not specified | not specifically |
| Artefact finds to be reported | yes; S10 | not specifically |
| State responsible for initiating research | yes; Ss10, 13 | not specifically |
| Education of public | not specified | not specifically |
| **Site protection and management** | | |
| All sites state property | no; but see S11 for Crown land | no |
| State responsible for site protection | yes; S7. if 'protected site'; S9. If 'relic'; S14 | no |
| Crown lands can be reserved | yes; S7 | no |
| Sites can be declared: (*a*) prohibited areas | no | no |
| (*b*) protected areas | yes; S7 | yes; S13 (d and c), S14 |
| Declared sites to be gazetted | yes; S7 | no |
| Declared sites to be signposted | may be; S18 | |
| Provision for purchase by authority | yes; S8 | yes; S14 |
| Provision for compulsory state acquisition | yes; S8 | yes; S18 |
| Compensation available to landholder | yes; S8 | yes; S18 |
| Entry may be restricted | yes; if 'protected site' S9 | yes; S29(2b) |
| Destruction, etc., prohibited | yes; S9 | no, only if site restored; S30(3) |

| | | |
|---|---|---|
| **Artefact protection and management** | | |
| Basic state ownership | no; but see S11 for Crown land | no |
| Private ownership permitted | yes; S21(3) | yes |
| Trading prohibited | yes; S14 | |
| Export prohibited | yes; S14 | |
| Provision for purchase by authority | yes; S8 | |
| Provision for compulsory state acquisition | no; but see S8 | |
| Compensation available to finder | no; but see S8 | |
| **Permission for archaeological survey/excavation** | | |
| Permit required for survey | no | |
| All excavation by state permit only | no | |
| Permit required for Crown land | yes; S14 | |
| Permit required for reserved land | yes; S14 | |
| Permission of landholder required | yes; S14 | |
| **Salvage of threatened sites** | | |
| Threatened sites to be reported | yes | |
| Developer to consult state authority | no | |
| State agencies responsible | no | |
| Developer responsible | no | |
| **Reports of research** | | |
| Preliminary report required within months | may be; S14 | |
| Final report required within two years | may be; S14 | |
| **Penalties provided for offences** | S20 (1975) and S44 (1970); (fine of up to $500 or 6 months' imprisonment or both) | |

The *Aboriginal Relics Preservation Act 1975;* the *National Parks and Wildlife Act 1970.*

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*Note:* Chapter submitted in November 1980. Revised in May 1982. Footnotes added in December 1982.

# Chapter 4

# Surveying techniques useful in archaeology

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Accurate maps, plans and sections showing the results of archaeological fieldwork or the results of an archaeological excavation are of first importance in recording a site. Although surveying often appears complex, no great knowledge of the subject is necessary to produce an essentially accurate map, plan or section.

Certain fundamental principles apply to all types of surveying whether it be the planning of a room or the mapping of an entire continent. These principles are as follows.

### (1) Always survey from the whole to the part or from the framework to the detail

This means a framework is surveyed and plotted first, then the desired detail is measured and fitted within this surrounding framework. If this procedure is not followed and a survey is begun at one point by drawing in the detail as one proceeds around the site, the resulting plan will bear little resemblance to the site being surveyed. By working inwards from the framework errors are kept to a minimum and no points of detail are badly out of position.

### (2) Independent checks must be made of all measurements whenever possible

In the type of surveying considered here, the most common checks required are usually a check on shape and a check on position.

(a) *Check on shape*

In Fig. 1 it is not sufficient to measure only sides *c* and *d* to ascertain its shape. Similarly, it is not sufficient to measure the sides *a*, *b*, *c* and *d* in Fig. 2 as it has the same length sides as Fig. 1, but a different shape. To prove or check the figure it is necessary to measure the diagonals *x* and *y* (Fig. 3) in addition to measuring the lengths of the four sides *a*, *b*, *c*, *d*.

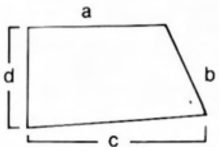


*Fig. 1*

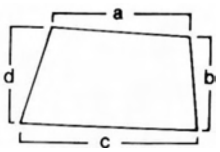


*Fig. 2*

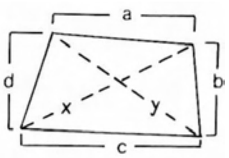


*Fig. 3*

(b) *Check on position*

Points of detail such as *P* in Fig. 4 are often 'fixed' from a baseline *AB* by measuring the tie-lines *a* and *b*. If one of these tie-lines is not measured correctly, the position of *P* will be plotted incorrectly. To provide a check the tie-line *x* is measured from a known point *C*, on the baseline *AB*. When *P* is being plotted, it is only when an arc is scribed with the radius *a* from *A*, *b* from *B*, and *x* from *C* that its position is adequately proved.

### (3) Maps and plans are two dimensional representations of three dimensional features

Thus they represent the distance between two points, as though they were at exactly the same level, and they do not represent the actual distance over the ground separating the points.

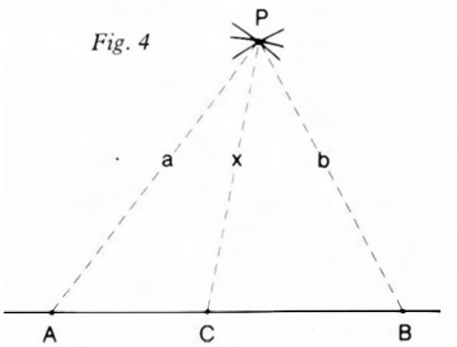
## THE PLAN: HORIZONTAL MEASUREMENT

### Scale considerations

In planning a site it is important to decide at what level of accuracy measurements should be made. This will be determined by the required degree of reduction on paper of the features measured in the field, and the further reduction required for possible publication. At a scale of, say, 1:200 a pencil line of 0.2 mm equals approximately 40 mm on the ground; at smaller scales of, say, 1:1000 or 1:2000 the same pencil line of 0.2 mm represents a far larger area of ground. Thus the degree of accuracy required of the surveyor becomes less as the scale decreases and the effect of the plotting error increases. Below is a table giving the approximate degrees of accuracy required at specific scales.

| *Scale* | *Accuracy of measurement* |
|---|---|
| 1:5 | to nearest 2 mm |
| 1:10 | 5 mm |
| 1:25 | 10 mm |
| 1:50 | 20 mm |
| 1:100 | 50 mm |
| 1:250 | 100 mm |
| 1:500 | 200 mm |
| 1:1000 | 500 mm |

*Fig. 4*



## Pacing

This method of measurement is extremely useful when making rapid site surveys, carrying out field reconnaissance, or resolving the question of scale rapidly when setting out a measured survey. To use one's pace as a means of measurement it is necessary to determine the pacing unit. This is best achieved by pacing a measured length of 100 m about 20 times to arrive at an average number of paces per 100 m length on straight and level ground. Further measured pacing is then carried out on rough ground, up hill and down slope. Each of these conditions will yield its own pacing unit and must be noted and remembered. Pacing is not accurate when carried out on extremely rough ground or steep slopes. However, when practised, pacing can be accurate to 5% or even better and is an extremely effective method of rapidly compiling a sketch map, particularly when used in conjunction with a prismatic compass.

## Chain surveying

This is the simplest and oldest form of land surveying. It is based on the principle that if a triangle is laid out on the ground and the lengths of its sides measured it may be later plotted in the drawing office to any desired scale.

### MEASURING EQUIPMENT

(a) *The steel band*

For long measurements a 6 mm wide steel band is used. These may be 30 m, 50 m, or 100 m long and are marked at 2 m intervals by brass studs sweated onto the band with the appropriate length engraved on them. At the head of the steel band is attached a 3 m 'leader' tape which is graduated in metres and millimetres. To measure a desired distance the tape is walked out, the person paying out the steel band then selects the nearest brass stud on the band and holds it against the mark on the ground. The band is pulled taut and the distance to the nearest 2 m is read off. At the head of the band the leader tape is then read where it cuts the mark and this reading is added to the measurement already determined, giving the total distance between the selected marks on the ground.

*Caution.* Steel bands must be handled with care because they may be easily snapped if pulled violently or allowed to develop kinks, as considerable pressure is applied to make sure that the band is taut when taking a long measurement. Also, they may be bent if drawn around a tight corner. When measuring distances of 60 m and upwards it is best to have an extra person midway to help manipulate the band and stop it sagging. When chaining a distance the band is pulled along the ground by the person leading, making sure the band remains relatively taut so as to reduce possible kinking and snagging. It is best to walk towards the end of the band when reeling it in, and if the band is wet it will be necessary to run it through an oily rag before storing it, as it will rust even overnight.

(b) *Tapes*

For most measurements a fibreglass or metallic tape 20 m or 30 m in length is recommended. Linen tapes tend to become inaccurate with moisture and age and should be avoided. For short measurements a carpenter's 5 m or 10 m, pocket steel tape is the most convenient. It is important to remove mud, sand, etc. from tapes after use. This is best done when reeling in the tape by running the tape through the first and second fingers of the hand holding the case; this will clear any grit or mud which might enter the case but great care should be taken with steel tapes. Walk up to the head of the tape, reeling it in as you go; do not drag the tape along the ground as this will soon obliterate the graduations.

*Caution.* Before using the tape, check to see that the zero of the graduation is at the outside end of the thumb-link, as some tapes are zeroed a short way in from the link.

*Ancillary equipment*

Ranging rods (Fig. 5) are used in chain surveying to mark conspicuous points. They are usually 2 m in length and painted with alternate red and white bands at 500 mm or 200 mm intervals and have a metal point on one end.

Chain arrows are used to mark ends of steel band lengths when chaining a line and to mark any temporary point required. They should be kept in bundles of 10 on a metal ring and have a red cloth tag attached to each so that they will be visible in the field. They should not be put down flat on the ground, as they will be continually mislaid and eventually lost.

Although not essential, the optical square and clinometer are very useful adjuncts in carrying out a chain survey. The optical square (p. 47) allows a right angle to be offset from a baseline quickly and accurately and over long distances. The clinometer (p. 54) allows angle of slope to be measured, so the horizontal distance may be calculated trigonometrically.

*Ranging a line*

In archaeological fieldwork it is often necessary to establish an accurate line of considerable length, *AB* (Fig. 6), from which offsets are dropped to points of detail. If the distance between stations *A* and *B* is considerable it will be necessary to establish intermediate points along the line by 'ranging' them in. To do this the surveyor stands about 1 m behind the ranging rod placed at station *A* and sights the distant rod placed at station *B*. The assistant holds a third (intermediate) ranging rod on the point on the line and is directed by the surveyor to move left or right to locate it in line with stations *A* and *B*. The signalling procedure is right or left arm held out to indicate movement to right or left and both arms held up when the position is correct. The surveyor can quickly see if the rod is truly on the line *AB* by rapid alternate viewing with right then left eye. When ranging a line with more than one intermediate point it is necessary to begin with the intermediate point furthest from the surveyor, otherwise sighting will be obscured. Fig. 6 shows the correct sequence for ranging in intermediate points viewed from station *A*.

*The principle of chain surveying* is to divide the area to be surveyed into a

*Fig. 5*

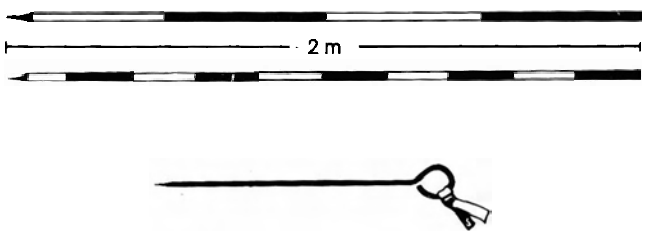



*Fig. 6*

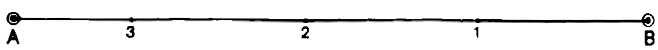
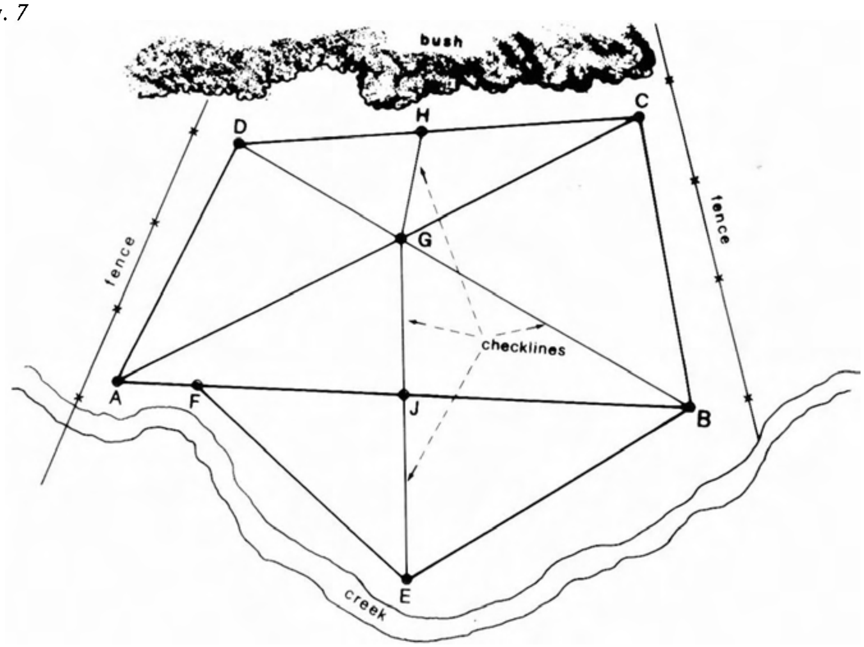


*Fig. 7*




framework of triangles, then measure all the sides. By measuring all the sides of the triangles a basic framework is established from which offsets may be measured at right angles to fix points of detail. To prove the accuracy of the framework it is necessary to range in and measure checklines across each triangle (Fig. 7).

PROCEDURE IN MAKING A CHAIN SURVEY

(1) Walk over the area, note its shape, its surface features, position of boundaries and suitable positions for survey stations and survey lines.

(2) Select the positions for the main stations carefully, as this determines the ease and accuracy of *all* subsequent work. Points to consider are:

(a) Use as few lines as possible to establish a rigid framework.
(b) The longest line is the baseline, it should run through the area (line *AC* in Fig. 7), forming a baseline on which subsequent survey lines are built.
(c) Angles in the triangles formed by the framework should be between 30° and 120° if possible.
(d) The lines should be on accessible ground and free from obstacles and as many as possible should be working lines from which offsets may be measured.
(e) Sufficient checklines should be provided (lines *DB*, *EG* and *GH* in Fig. 7).

*Measuring a chain line*

Once the layout of the chain survey has been decided and the station pegs fixed in position, the sides of the triangles formed are measured using a steel band or a surveyor's tape. A minimum of two people is required for this operation, one, the leader, who takes the outer end of the steel band or tape and a set of 10 chain arrows; the other, the follower, who will book the measurements as well as assist in manipulating the steel band. The leader walks out with the head of the steel band in the direction of the line to be measured. When the band is at its limit the leader stands to one side and is directed by the follower until the band is accurately on the line. An arrow is placed on the line and the band pulled tight by the leader whilst the follower holds it against the mark. The leader then removes the arrow and places it in the ground at the end of the band. The leader then moves off towards the sighting station and the follower again sights the leader in, this time from the first arrow position. The leader places a second arrow and once this is accurately and firmly positioned, the follower collects the first arrow and keeps it. By this method of the leader fixing the arrows and the follower collecting them, an accurate check may be kept of the steel band or tape lengths measured. After the tenth length is measured the leader proceeds on to the eleventh point. As the leader now has no arrows left the follower removes the tenth arrow and replaces it with a *different* temporary marker, he then gives a set of 10 chain arrows to the leader and measurement continues from the temporary marker. The survey follower notes each time 10 lengths have been measured.

It is important to note that the linear measurements in all surveys are always taken as the horizontal distance between two points. Therefore, when the ground is sloping between the points, it is necessary to obtain the true horizontal distance. This may be achieved using either the stepping and plumbing method, or by measuring along the slope and calculating the true horizontal distance.

*Stepping and plumbing*

This method is useful when the slope is not uniform. It is best to lay the steel band on the ground to indicate the line direction, and to use a 30 m surveyor's tape for the stepping and plumbing. The follower holds the tape on the ground while the leader holds out the desired length of tape keeping it level and plumbs down with a plumb-bob to the ground where he fixes an arrow. The follower can ascertain if the tape is horizontal by checking that its angle to the plumb line is 90° when the measurement is being made. It is easiest to work downhill in regular steps of 10 m or 20 m; however, the size of the steps will depend on the angle of slope and the need to keep the tape horizontal (Fig. 8).

*Measuring along a slope*

This method is valuable because it saves a great deal of time when compared to the stepping and plumbing method. However, it is only accurate if the slope being measured is relatively uniform, or at the most has only a couple of changes in slope.

The measurements are made directly along the surface of the ground and the corresponding true horizontal distances calculated using either a clinometer (p. 54) or an Abney level (p. 53). These

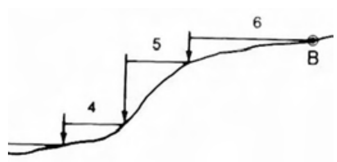
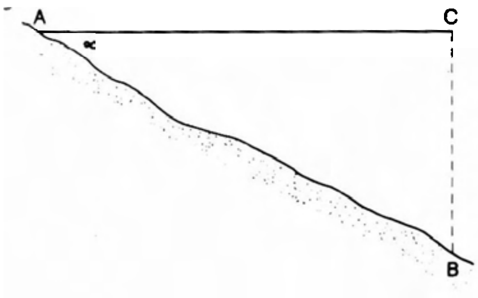


*Fig. 9*




instruments enable the angle of slope to be determined. For example, the slope distance *AB* in Fig. 9 is measured and found to be 18.70 m. Then the angle of slope is measured and found to be 29°. The cosine is found corresponding to 29° which is 0.8746. The distance 18.70 is multiplied by 0.8746 giving the horizontal distance, *AC*, of 16.36 m. The trigonometric relationship is as follows: if $AB$ = the slope distance, $AC$ = the horizontal distance, and $\alpha$ = the angle of slope, then $\frac{AC}{AB} = \cos\alpha$, therefore $AC = AB\cos\alpha$. The true horizontal distance is thus calculated for uniform slopes (see Appendix 1 for table of cosines corresponding to degrees of slope).

*Offsets*

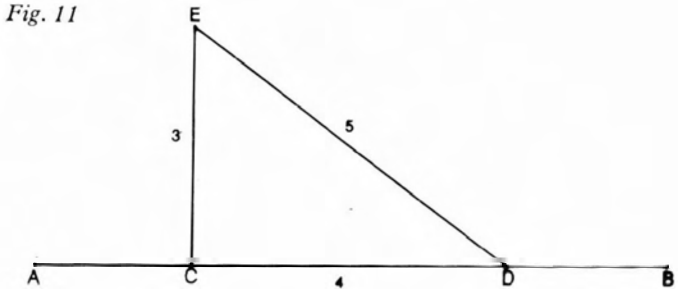
To fix points of detail, such as locating the actual boundaries of a survey or plotting archaeological features, perpendicular measurements called 'offsets' are made from or to the chain lines. These may be made in a number of ways using either the surveyor's tape or optical instruments. This method is only of value if the offset is at right angles to the chain line. If the chain lines of the survey are placed so that they run close to boundaries and features to be plotted, offset procedures can be considerably reduced. Short offsets of up to 3 m may be estimated by eye for perpendicularity in surveys at small scales, beyond this other methods should be used.

*To erect a perpendicular from a point on the chain line using a tape*

There are two methods which can be used. In the first (Fig. 10) *AB* is the chain line and *C* the point from which a perpendicular is to be erected. Equal distances are measured along the chain line either side of *C*, say 10 m, and marked with chain arrows. The thumb-link at the head of the tape is fixed by one of these arrows and the 40 m mark on the tape is held or fixed to the other arrow. The surveyor then holds the 20 m mark on the tape and moves away from point *C* until the tape is taut, an arrow is put in to mark point *D*, *DC* will now be perpendicular to *AB*.

The second method uses the 3–4–5 principle (Fig. 11).

*Fig. 11*




From point *C* on the line *AB* a distance not less than 4 m, or a multiple of 4 m not greater than 16 m, is measured and point *D* marked with an arrow. The tape is pinned at *C* and a distance twice that of *DC* (8 m) is paid out, the 8 m mark being secured at *D*. The mark on the tape representing 3 m or its multiple is held by the surveyor and moved away from *C* until it is taut. An arrow is put in to mark *E*, *CE* is now perpendicular to *AB*.

*To drop a perpendicular to the chain line from a point outside it*

Using the tape two methods can be employed. In the first, the thumb-link of the tape is pinned at point *C* with an arrow and uniform arcs are struck so that they cut the chain line *AB* (Fig. 12). The distance between these two points is measured along the line *AB* and bisected to give *D* which is then marked with an arrow, *CD* is now perpendicular to *AB*.

With the second method (Fig. 13) the 20 m mark on the tape is fixed at point *C*, the tape is pulled taut and the zero end pinned with an arrow on the line *AB* where it cuts it. At the 10 m mark on the tape a second arrow is fixed, *D*, then the 20 m mark at *C* is released and the tape swung down on to the line *AB*, pulled taut, and point *E* marked with an arrow. *CE* is now perpendicular to *AB*.

*Triangular offsets*

Where a feature lies far from the line, it is often more accurate to fix it by triangular offsets than to drop a perpendicular, unless optical instruments are available. To fix a feature in this way two points are selected along the line and the feature is fixed by direct measurements from these points. The position of the feature is later plotted by compass intersection on the plan at the desired scale. The accuracy of this method is largely dependent on the size of the receiving angle. This angle should not be less than 40° or greater than 140°, the nearer it is to 90° the greater the accuracy in fixing

*Fig. 10*

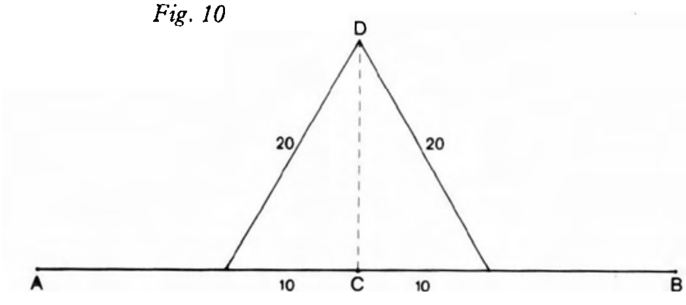



*Fig. 12*

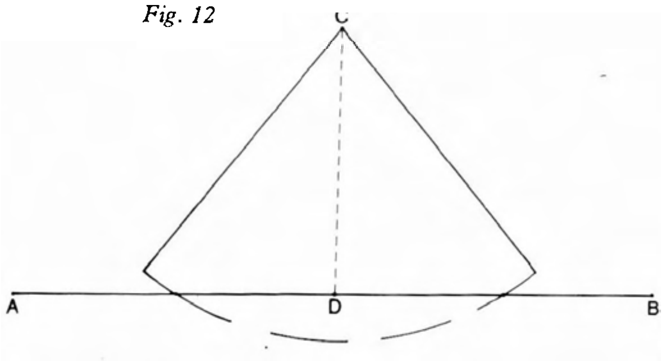


*Fig. 13*

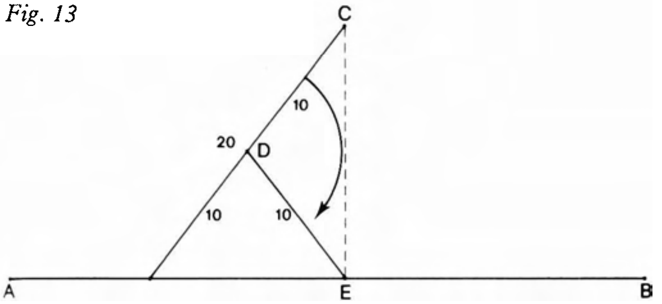
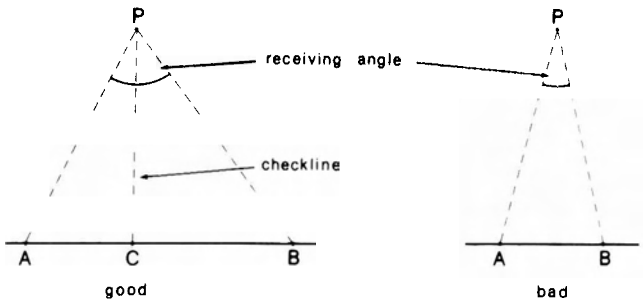



*Fig. 14*




*P*. It is best practice to fix *P* by dropping a third 'checkline' (*PC* in Fig. 14) to the line. It is important also, that each measurement is taken to the same point *P;* on archaeological sites features are often indefinite and thus should be marked with a chain arrow or some similar marking device.

*Optical instruments*

Offsets can be located accurately using optical instruments such as the cross staff and the optical square. For long offsets these instruments are recommended. A simple form of cross staff is easily made by driving nails partway into each corner of a small board about 15 cm square, which is mounted on a pole at normal eye level (Fig. 15).

To use the cross staff, set up on chain line *XY* (Fig. 16) at point *A,* from where the new line is to be set off. Place a ranging rod at *B* on line *XY,* some distance from *A,* sight the cross staff on it and without moving the cross staff, sight through the second pair of diagonal nails in the direction of *C* and direct an assistant with a second ranging rod until this rod is in line with the nails. The line *AC* will then be at right angles to line *XY*.

The optical square is the easiest to use and the most accurate instrument for locating offsets. There are two forms of this instrument, one using mirrors and the other using a pentagonal prism. The mirror type operates on the principle that a ray of light is reflected at exactly the same angle as that with which it strikes the mirror.

The instrument is held over the point *C* on the line *AB* (Fig. 17) from which a line *CD* is required to be set off at right angles. A ranging rod at *B* is sighted through the lower part of the mirror *Z*, and another rod, held in the area of *D,* is moved until its image in the upper half of the mirror *Z* coincides with the rod at *B*.

The prism type of optical square consists of either one or two pentagonal prisms, the only difference being that the pair of prisms allows offsets to be made both to the right and left of the line without having to turn the instrument upside down as with the single prism.

To make an offset the ranging rod *A* (Fig. 18) is observed through a peephole above the prism and brought into coincidence with the reflection of ranging rod *B* seen through the prism.

As well as setting offsets from a point on a line, the optical square has the advantage that it can indicate to the observer that exact point on a chain line where a perpendicular, dropped from a point well outside the line, will land. To do this the observer walks along the chain line keeping the rod *A* (Fig. 18), at the end of the chain line, in the centre of the peep sight above the prism, until the reflection of the other rod at *B* coincides with it. When this occurs the observer is at the point where the perpendicular falls.

*Booking the chain survey*

The chain survey is recorded in a field book which is about 100 mm × 200 mm in size and opens lengthways. It has two red lines running vertically down each page which represent the chain line; all chain distances are entered between these lines whilst the space either side is used for sketches of features being located and the measurements of their offsets. Entries in the field book are commenced at the back and continued towards the front, they are booked from the bottom of the page upwards following the path worked by the surveyor. It is best to face in the direction the line is being chained to avoid booking on

*Fig. 15*

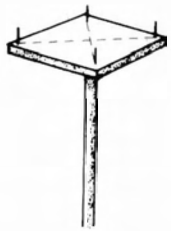


*Fig. 16*

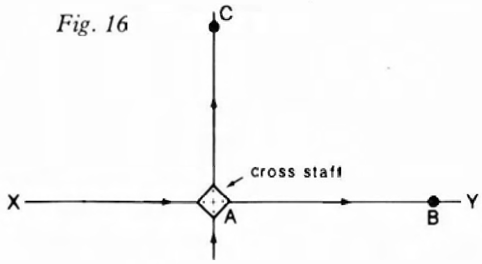



*Fig. 17*

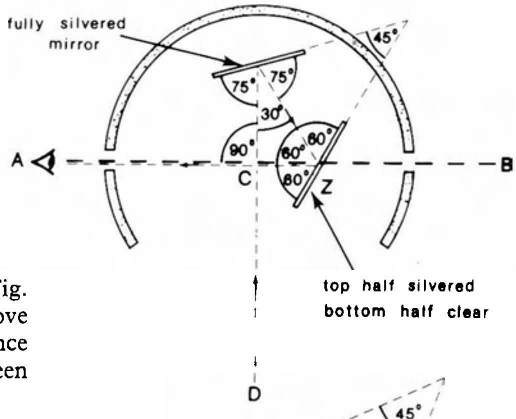
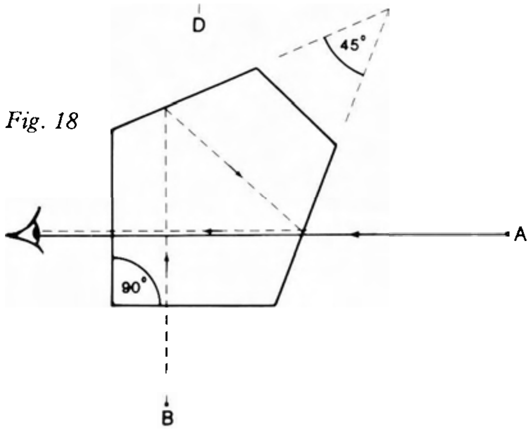



*Fig. 18*



the wrong side of the line. Before commencing measurement a sketch of the layout of chain lines is made on the last page of the field book, together with the survey title, the date and name of the surveyor (Fig. 19).

Survey stations are identified with letters, and arrows are drawn on main survey lines to indicate direction of measurement; the longest line of the survey is usually taken as the base line and is measured first. Sketches will also be necessary of the survey stations which will be 'tied' to permanent points (Fig. 20). Two 'ties' are necessary, three are preferable.

Any notes made must be clearly expressed and written. Sketches should be kept in their relation to the chain line but may be exaggerated sideways to allow more space so as numbers are clear. The notes, sketches and bookings must be clear enough for another person to plot the survey accurately.

*Plotting the survey*

This part of the survey is usually carried out in the office as soon as possible after the fieldwork is completed. Before plotting the survey it is necessary to determine the scale to be used, this will have already been considered by the surveyor when deciding the degree of accuracy to work to (p.43). The next step is to calculate and note the maximum dimensions of the plan, allowing for a margin around the edge and orienting

*Fig. 19*

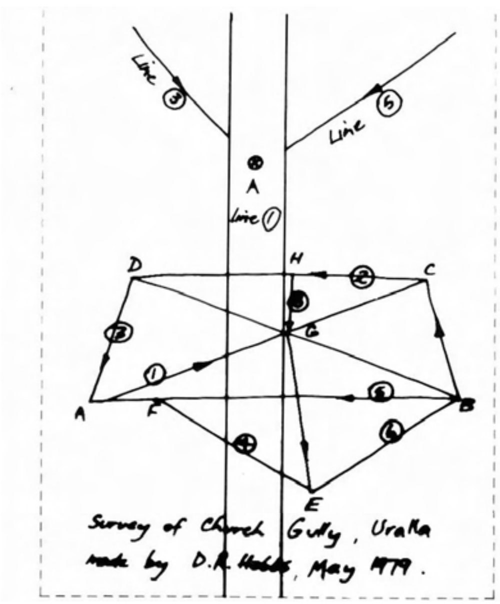
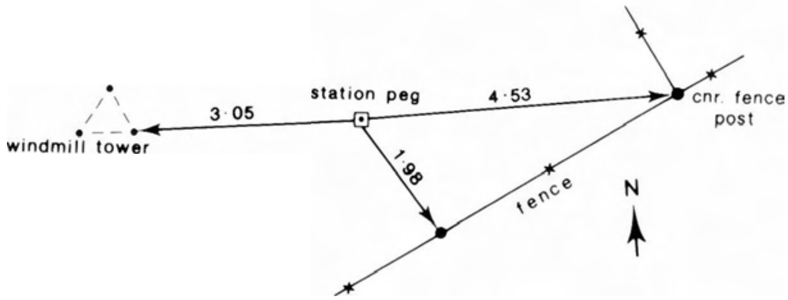



*Fig. 20*




it so that the north lies at the top of the page if possible. Space should also be left for a scale at the bottom and a title at the top if it is necessary.

The scale to be used is fixed and drawn at the bottom of the page. The base line (the longest line) is drawn first, then the end stations are plotted, followed by the intermediate stations. The main triangles attached to the base line are located by striking intersecting arcs with the beam compass. Then the checklines are added to verify the triangles. Any remaining triangles or auxiliary survey lines are added and when satisfied that the framework is correctly plotted, the detail is added. This is done by scaling the lengths noted on the chain lines where the offsets were taken, then using a set square to erect perpendiculars along which the offset lengths are drawn to scale.

After the plotting is completed, the title, the direction of north, and the scale are added to the plan. The final tracing is then made omitting the survey gridwork.

*Possible sources of error in chain surveying*

(1) Omitting to book one or more band or tape lengths,

(2) misreading band or tape,

(3) incorrect booking,

(4) mistaking dimensions when called out,

(5) incorrect marking of band or tape end.

*Cumulative errors*

Positive errors, causing measurement to be too large:

(1) Not allowing for slopes when the slope exceeds 3° per tape length,

(2) stretching of tape,

(3) tape bellying out in the wind.

The permissible error in chain surveys is 1 in 500.

## LEVELLING: VERTICAL MEASUREMENT

### Datum

Before the relative heights can be depicted on a map or section some arbitrary plane must be established to which all heights may be referred. For surveying an archaeological site it is convenient to adopt some arbitrary datum such as the lowest, firm and permanent point on the site. Although this adopted datum will be used as the zero height for recording all other heights it is not a suitable zero from which to measure them. For that purpose a horizontal reference plane is required, spread like an imaginary flat canopy over the site, from which relative heights may be measured by means of a graduated rod or levelling staff (Fig. 25).

### Level

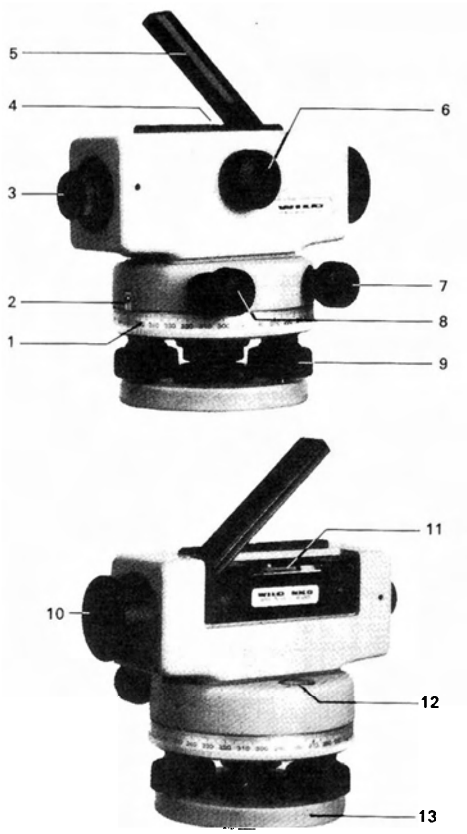
The instrument used to establish this covering plane is the level, which consists of a telescope attached to a spirit level which is mounted on a tripod and free to rotate in a horizontal plane about a vertical axis (Fig. 21). The telescope is fitted with cross-hairs. If the vertical axis is truly vertical the line of sight, joining the intersection of the cross-hairs with the telescope object lens, will sweep out a horizontal plane as it rotates about the axis. This plane is called the line of collimation. To enable the vertical axis to be adjusted to a truly vertical position three adjustable footscrews are provided in the base plate of the instrument and a small circular spirit level built into the body of it.

#### TYPES OF LEVEL

There are four main types of level likely to be used on archaeological sites: the Dumpy level, the Tilting level, the Quickset level and the Automatic level.

(1) *The Dumpy level* is the most basic type. It consists of a telescope, with an attached tubular spirit level,

*Fig. 21*




1 Horizontal circle
2 Index for reading the circle
3 Telescope eyepiece
4 Open sight, with notch marking instrument centre
5 Mirror for viewing tubular level
6 Focussing knob
7 Horizontal drive screw
8 Tilting screw
9 Footscrew
10 Telescope objective
11 Tubular level
12 Circular bubble
13 Base plate

mounted on a base plate with three footscrews to level the instrument.

(2) *The tilting level* is the most common type. It has a circular 'bull's-eye' spirit level on the base of the instrument which is centred roughly by the three footscrews as above. The instrument is then levelled accurately for each sighting by a tilting screw, usually placed under the eyepiece of the telescope, which centres a second bubble in the tubular spirit level mounted beside the telescope.

(3) *The Quickset level* is a particular type of tilting level where the three footscrews are replaced by a ball and socket for quick levelling up using the circular bull's-eye spirit level.

(4) *The automatic level* is the most recent innovation in which there is an optical-mechanical compensator which automatically sets the line of sight horizontal. The instrument is levelled by approximately centering a circular bull's-eye spirit level with three footscrews, the readings are then taken without any further fine adjustment.

TO SET UP THE LEVEL

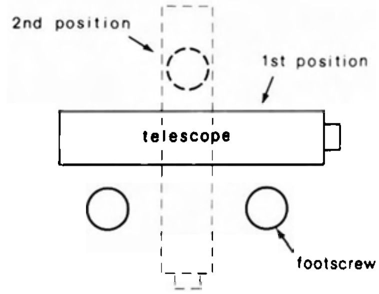
Choose a position on firm ground from which the horizontal line of sight will be above all the points whose heights are required. Plant the tripod legs firmly so that the top of the tripod is as near horizontal as possible, then firm in the legs by means of the footsteps provided at the bottom of each leg. The instrument is then attached to the tripod, securing it in place with the central retaining screw attached to the underside of the tripod head. Some instruments have sharp V-shaped lugs under the ends of the levelling screws and care must be taken to make sure these are located in the grooves cut in the tripod head before tightening the retaining screw.

The next step is to level the telescope using the three footscrews (Fig. 22). First turn the telescope so that it lies parallel to any pair of the three screws; these two are then turned in opposite directions, until the bubble is brought into the centre of the circle in the small circular bull's-eye spirit level. Once the bubble is centred, turn the telescope through 90° and level up using only the third screw which lies beneath the telescope. The telescope is then moved around again, over each screw until all minor adjustments have been made and the bubble remains centred in any telescope position.

FOCUSSING THE INSTRUMENT

This is a three-step process. First, the cross-hairs are focussed by turning the eyepiece until they are seen to be sharply defined. The staff is then sighted and the

*Fig. 22*




telescope focussed onto it by turning the milled screw mounted on the right-hand side. Finally, the focus must be tested for parallax error by sighting the staff through the telescope and moving the eye slightly. If the cross-hairs appear to stay fixed on the staff there is no parallax error present, but if there is movement it is present and must be eliminated. To do this, turn the focussing screw until no object can be seen in the telescope, turn the eyepiece to bring the cross-hairs into sharp definition, then focus the telescope upon the staff again and test as before. Note that when the correction for parallax is made, it is fixed for the particular observer's eyesight.

LEVELLING

The level is now ready for observation. To take a level, place the graduated staff on the feature whose height is required and observe the reading on the staff cut by the *centre horizontal cross-hair* of the telescope (Fig. 24). Make sure that the bubble in the spirit-level attached to the side of the telescope is in its central position *before* and *after* the reading. This reading gives the depth of an object below the line of collimation and by moving the staff from one feature to another a series of depths below the horizontal plane, swept out by the line of collimation, will be given from which a section may be drawn (Fig. 23).

*Fig. 23*

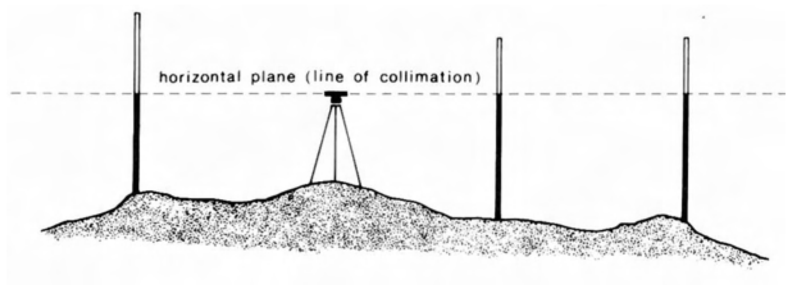
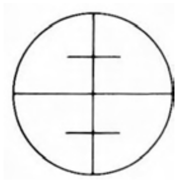


*Fig. 24*



SOURCES OF ERROR

(1) *Incorrect readings taken.* There are usually three horizontal hairs in the level telescope, constant care must be taken to read only the long centre hair (Fig. 24). For the use of the two short stadia hairs see page 59.

(2) *Some levels do not have self-erecting eyepieces,* so that everything viewed through them appears upside-down. However, once one becomes adjusted to reading the inverted scale it will hardly be noticed.

(3) *Parallax error.* Adjust as previously described under Focussing the instrument.

(4) *Errors in booking*

(5) *Instrument moved* or bumped during readings of backsight and foresight.

(6) *Staff moved* during changeover of level position.

(7) *Jammed telescopic staff.* If a telescopic staff is used, make sure it is properly extended and not jammed in an incorrect position.

(8) *Confusion of graduations.* There are a number of types of graduation used on staffs, which tend to be confusing at first. However, they are all designed to be read over a considerable distance with minimum confusion and with a little practice are straightforward to use (Fig. 25).

In Fig. 25 the most common types of metric graduation are shown. Care should be taken when familiarising oneself with the staff graduations. For example types B and C, whilst similar in appearance, are graduated differently. Type B is in metres and 10 mm units and type C in metres and 5 mm units, both these types have the metre reading in red and the millimetre readings in black.

Type RU is the standard metric 'E' pattern graduated in metres and 10 mm units, alternate metres are in red and black with full reading to 10 mm repeated. This type is the easiest to read, particularly where shooting long sights.

(9) *Verticality of staff.* It is most important that the staff is held vertically. The vertical cross-hair in the telescope will show whether the staff is leaning to one side but there is no way to show whether the staff is leaning away from or towards the instrument, allowing a wrong level to be taken. To avoid this situation the staff-holder should move the staff gently towards and away from the instrument; the least reading observed on the staff, whilst the swaying is in progress, is the correct one.

(10) *Centrality of spirit level.* The tubular spirit level attached to the telescope of the level is extremely sensitive and must be checked for centrality *before* and *after* each reading. To do this a mirror or prism is fitted to instruments to allow the bubble to be seen from the eye-end of the telescope. With instruments using a mirror the reflection of the whole bubble can be seen, and since the tubes are engraved with graduations it is a simple matter to see if the bubble is central (Fig. 26). In instruments using a prism system both ends of the bubble are seen together; to centre the bubble the two ends are brought into coincidence so that they form a smooth curve (Fig. 27). Should both ends of the bubble be out of sight it is necessary to step to the side of the instrument where the whole bubble can be seen.

(11) *Poor reading due to climatic conditions:* heat haze, bad light, etc. In this case reduce the length of the sights. The maximum permissible length of sight with an ordinary instrument under reasonable conditions is 100 m.

(12) *Collimation error.* To reduce this error keep the length of backsights and foresights roughly equal. See Appendix 3 to check for this error.

(13) *Loose tripod head.* Tighten screws fixing legs to tripod head.

(14) *Telescope not parallel to bubble tube.* Check and adjust as necessary using permanent adjustment No. 1 (see Appendix 3).

(15) *Telescope not at right angles to the vertical axis.* Check and adjust as necessary using permanent adjustment No. 2 (see Appendix 3).

*Fig. 26*

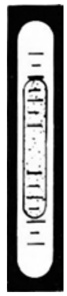
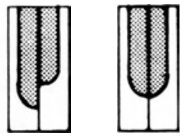


*Fig. 27*



DIFFERENCES OF LEVEL BETWEEN TWO POINTS

This is the simplest operation in levelling from which all other operations derive. There are three methods which may be used:

(1) The level is set up over point *B*, then the height of the instrument (*J*) above

*Fig. 25*

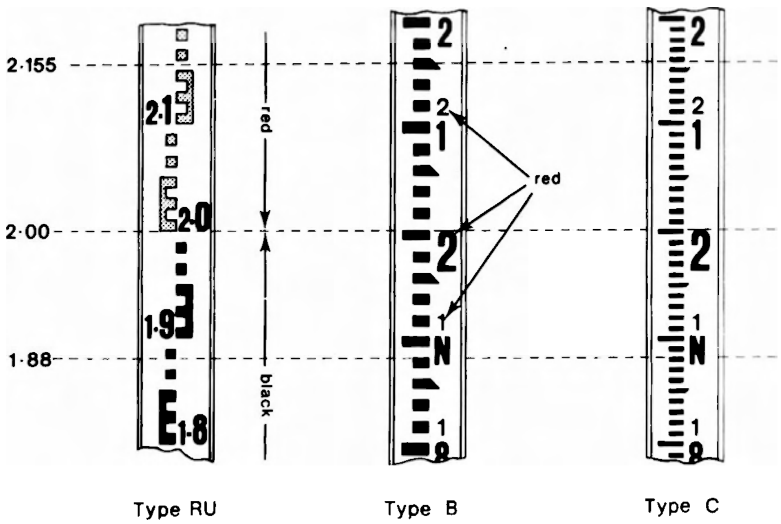


*Fig. 28*

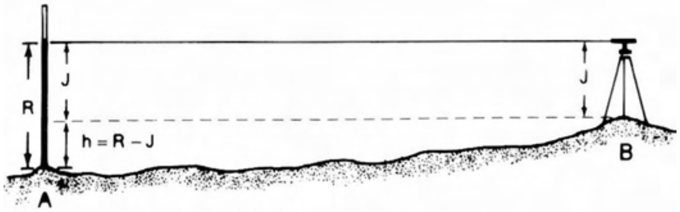



*Fig. 29*

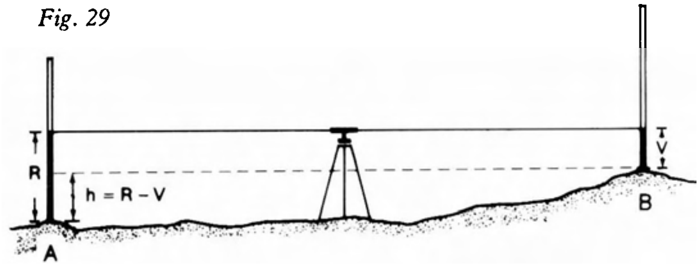



*Fig. 30*

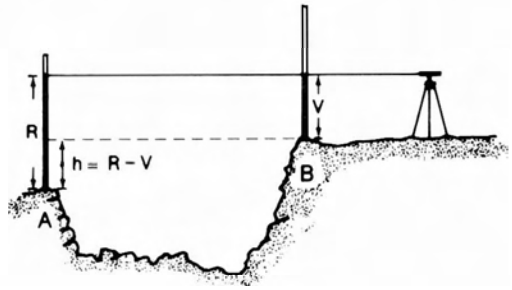
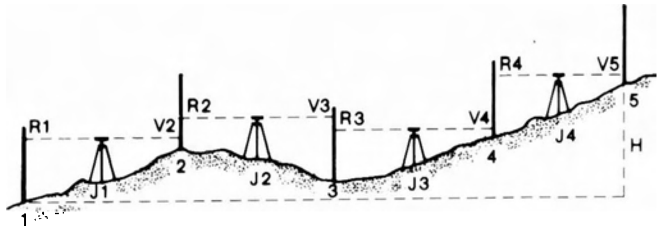



*Fig. 31*




the ground is measured with a tape (from ground level to the centre of the level eyepiece). The staff is held at point *A* and a reading taken (*R*), the difference in height (*h*) between *A* and *B* is found by subtracting the height of instrument (*J*) from the staff reading (*R*), thus $h = R - J$ in Fig. 28.

(2) With this method the level is set up approximately midway between points *A* and *B* and readings taken on the staff held over these points. The difference between *R* and *V* in Fig. 29 gives the difference in height (*h*) between points *A* and *B*, thus $h = R - V$.

(3) This method is useful where obstacles do not allow the previous methods to be used. In the case shown in Fig. 30 the level is set up on firm ground where both points *A* and *B* may be sighted. The staff is held over points *A* and *B* and readings taken at each. The difference between the readings gives the difference in height (*h*) between points *A* and *B*, thus $h = R - V$.

SERIES LEVELLING

This levelling operation is used if the two points whose levels are to be measured are some distance apart, or where there is no position for the level where both points are visible. To do this the staff is held on station 1 and the level set up about 50 paces away at *J1* roughly in the direction the traverse is desired to go. A reading is taken on the staff *R1* and 'booked' as the 'backsight'; the staff is then moved forward about 50 paces beyond the level to station 2 and a reading is taken on it *V2* and booked as the 'foresight'. The level is then moved forward about 50 paces beyond the staff to *J2* while the staff remains in its position and is carefully turned to face the new level position. (It is important to note that the staff and level must never be off the ground at the same time.) When the level is set up in its new position a backsight *R2* is taken on the staff and booked and the staff moved to its new position at station 3 about 50 paces beyond the level and the foresight *V3* taken. This cycle of 'stepping' the level and staff, is repeated until the desired station, whose difference in height is required, is reached. Fig. 31 illustrates this process and Fig. 32 shows how readings should be booked.

All the backsights are added together and all the foresights are added; the difference between these two sums gives the difference in height between station 1 and the selected spot station 5. If the sum of the foresights is greater it means that the destination is lower than the starting point and vice versa.

*Fig. 32*

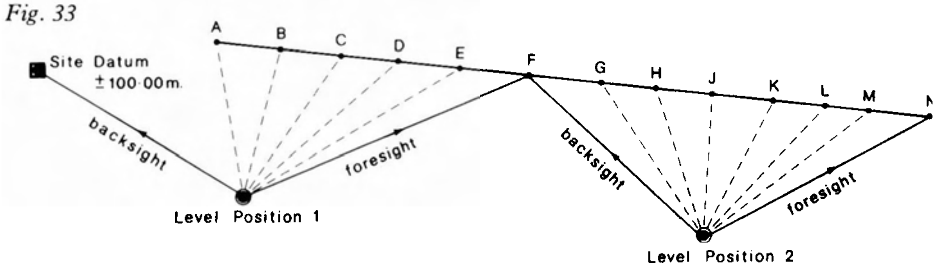
| Point No. | in Fig.31 | Backsight R | Foresight V |
|---|---|---|---|
| 1 | R1 | 2·58 | |
| 2 | V2 | | 0·37 |
| 2 | R2 | 1·17 | |
| 3 | V3 | | 2·69 |
| 3 | R3 | 2·14 | |
| 4 | V4 | | 0·29 |
| 4 | R4 | 2·35 | |
| 5 | V5 | | 0·26 |
| | | 8·24 | 3·61 |

8·24
− 3·61
+4·63 = diff. in height

RUNNING A SECTION

Often in surveying an archaeological site it is necessary to establish levels over a line through the site or area, in order to produce a section. The same procedures apply as

*Fig. 33*



above, except that the line itself will be accurately ranged and chain arrows placed at points whose height is required (Fig. 33).

To run a section for levels, position the level so that a number of the points can be seen and an arbitrary height (in this case the site datum) is established on or near the line. In the example shown in Fig. 33 the staff is placed on the site datum and the reading is taken from level position 1 and is booked as a backsight. The staff is then moved to positions on the line at *A*, then *B*, then *C*, and so on, until position *F* is reached. The positions *A*, *B*, *C*, *D*, and *E* are booked as 'intermediate sights' or 'inter-sights' (see Figs. 34 and 35 for booking procedures). On sighting position *F* it is found that the staff is becoming difficult to read so the level must be moved. Position *F* is booked as a foresight, the staff remains in its position and is carefully turned to face the new level position. The level is moved to the new position (level position 2 in Fig. 31), levelled, then sighted back onto *F*. The reading is booked as a backsight, on the same line as the booked foresight for *F*, as they both refer to the same position. The staff is then moved to positions *G*, *H*, *J*, *K*, *L* and *M* which are booked as inter-sights and the final position *N* is booked as a foresight. (Note that it is customary to omit the letters I and Q from such designations, because of the possibility of confusing them with the numbers 1 and 0.)

*Fig. 34*

| Level Posn. | Back Sight | Inter Sight | Fore Sight | Rise (+) | Fall (−) | Reduced Level | Remarks. |
|---|---|---|---|---|---|---|---|
| 1. | 2.34 | | | | | 100.00 | Site Datum ±100.00 |
| (in Fig. 33) | | 3.22 | | | 0.88 | 99.12 | Posn. A |
| · | | 2.12 | | 1.10 | | 100.22 | · B |
| " | | 4.03 | | | 1.91 | 98.31 | · C |
| · | | 3.34 | | 0.69 | | 99.00 | · D |
| " | | 2.96 | | 0.38 | | 99.38 | · E |
| 2. | 3.28 | | 4.23 | | 1.27 | 98.11 | · F (Level Posn. Changed) |
| · | | 3.56 | | | 0.28 | 97.83 | · G |
| " | | 3.62 | | | 0.06 | 97.77 | · H |
| " | | 4.08 | | | 0.46 | 97.31 | · J |
| " | | 3.24 | | 0.84 | | 98.15 | " K |
| " | | 3.22 | | 0.02 | | 98.17 | · L |
| · | | 3.72 | | | 0.50 | 97.67 | · M |
| · | | | 3.86 | | 0.14 | 97.53 | " N |
| | 5.62 | | 8.09 | 3.03 | 5.50 | 100.00 | First Red. Lev. |
| | | | -5.62 | | -3.03 | -97.53 | Last Red. Lev. |
| | | | 2.47 | | 2.47 | 2.47 | |

BOOKING PROCEDURE

There are two methods used to book levels; the rise and fall method and the collimation method. In the rise and fall method entries are booked as in Fig. 34.

In this example, levels are recorded in one of the columns 2–4 depending on whether they are backsights, inter-sights or foresights; with the last reading booked as a foresight for ease in checking for errors. The reduced level is obtained for each position by calculating its height in relation to the position immediately preceding it, whether a backsight or inter-sight. In Fig. 34 the staff reading at position *A* of 3.22 is compared with the backsight reading of 2.34; the difference is 0.88 and is booked as a *fall* as the reading at *A* is greater and therefore lower. A *fall* is *subtracted* from the known reduced level assumed for the site datum, in this case 100.00 m, thus the reduced level of position *A* is 100.00 − 0.88 = 99.12. At position *B*, the difference between position *A* (3.22) and position *B* (2.12) is 1.10. The reading of 2.12 for position *B* is less than the preceding reading for *A* (3.22) and is thus a *rise*. A *rise* is *added* to the preceding reduced level obtained for position *A* (99.12 + 1.10 = 100.22) to obtain the reduced level for *B*. The entry for position *F* has both a backsight and foresight recorded on the same line. This is where the level position was changed (Fig. 33) and a foresight was recorded for *F* at level position 1 and a backsight recorded for *F* at the new level position 2. When a level change is made the reduced level is obtained from the difference between the previous reading for position *E* and the foresight taken onto position *F*. The backsight for position *F* is used to compare with the subsequent reading taken at position *G* from the new level position in order to obtain the reduced level for position *G*.

Checks on the accuracy of the arithmetic must be carried out to test for any errors in the booking of the levels. With the rise and fall method the difference between the sum of the backsights and the sum of the foresights must equal the difference between the sum of the rises and the sum of the falls, and the difference between the starting reduced level and the final reduced level.

In the collimation method entries are booked as follows in Fig. 35.

The first reading 2.34 is a backsight and is entered in the backsight column. The sight is taken onto the site datum, which in this example has an arbitrary reduced level of 100.00 m. This reduced level is entered in the reduced level column. The sum of the backsight and the reduced level give the height of the instrument as 2.34 + 100.00 = 102.34, which is entered in the height of instrument column. The next sight is an inter-sight to position *A* and is entered in the inter-sight column. The difference between the inter-sight and the height of the instrument gives the reduced level of position *A* which is 102.34 − 3.22 = 99.12. This quantity is entered in the reduced level column for position *A*. When a foresight is taken its level is reduced in the same way as an inter-sight. When the level position is changed a backsight is taken onto the position on which the last foresight was taken (position *F* in Fig. 33). It is entered on the same line as the foresight in the backsight column. The new backsight (3.28) is added to the reduced level calculated for position *F* (98.11) and a new

*Fig. 35*

| Level Posn. | Back Sight | Inter Sight | Fore Sight | Height of Instrument | Reduced Level | Remarks. |
|---|---|---|---|---|---|---|
| 1. (in Fig. 33) | 2·34 | | | 102·34 | 100·00 | Site Datum ± 100·00 |
| | | 3·22 | | | 99·12 | Posn. A |
| " | | 2·12 | | | 100·22 | " B |
| " | | 4·03 | | | 98·31 | " C |
| " | | 3·34 | | | 99·00 | " D |
| " | | 2·96 | | | 99·38 | " E |
| 2. | 3·28 | | 4·23 | 101·39 | 98·11 | " F } Level Posn Change |
| " | | 3·56 | | | 97·83 | " G |
| " | | 3·62 | | | 97·77 | " H |
| " | | 4·08 | | | 97·31 | " J |
| " | | 3·24 | | | 98·15 | " K |
| " | | 3·22 | | | 98·17 | " L |
| " | | 3·72 | | | 97·67 | " M |
| " | | | 3·86 | | 97·53 | " N |
| | 5·62 | | 8·09 | | 100·00 | First Red. Lev. |
| | | | -5·62 | | -97·53 | Last Red. Lev. |
| | | | 2·47 | | 2·47 | |

height of instrument obtained (101.39). Any subsequent foresights and inter-sights are reduced by subtracting them from this new height of instrument and the process is repeated as far as is necessary.

*To check the accuracy of the reduction*

The difference between the sum of the backsights and the sum of the foresights should equal the difference between the first and last reduced levels. This method is quicker to reduce than the rise and fall method but does not check the reduction of the inter-sights.

*Note.* When a considerable number of readings are taken several pages of the level book will be used. For ease of checking the level reduction each page may be checked separately if it begins with a backsight and ends with a foresight. If an inter-sight comes at the end of a page, enter it as a foresight on that page and as a backsight on the next.

PLOTTING A SECTION

To produce a final drawing of the section run (Fig. 33) the line of collimation is ruled lightly on squared paper and all heights recorded measured down from it at the desired scale. It is not necessary for the vertical scale to be the same as the horizontal scale; in the case of very large scale drawings it is usually better to use the same scales, but in small scale work a truer impression of what the section really looks like is obtained if the vertical scale is exaggerated in the ratio of 2 : 1 or 3 : 2. The scales used need to be clearly stated on the finished drawing and it is a useful guide to the eye if both the horizontal and vertical scales are drawn as shown in Fig. 36.

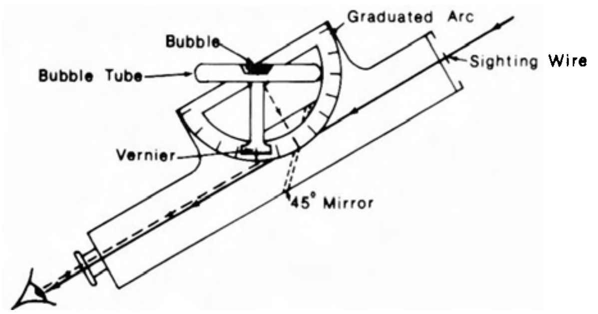
OTHER TYPES OF LEVELLING INSTRUMENTS

*Hand levels*

These are the simplest form of instrument for determining levels, they have practical value in that they are compact, robust and lightweight, taking up little room in a backpack.

The simplest form of hand level consists of a square-sectioned tube fitted with an eyepiece at one end and cross wires at the other. A tubular spirit level is mounted on top of the tube and is reflected into the field of view through the tube by a mirror set at 45°. To take a level the instrument is sighted through, and moved up or down until the reflection of the bubble is central. This indicates that the instrument is horizontal and where the cross wire cuts the staff is on the same height as the level. It is best to use a wooden pole about 1.5 m in height (eye-height) on top of which to steady the instrument so that accurate readings may be taken. The level may be used with a graduated staff or a ranging pole.

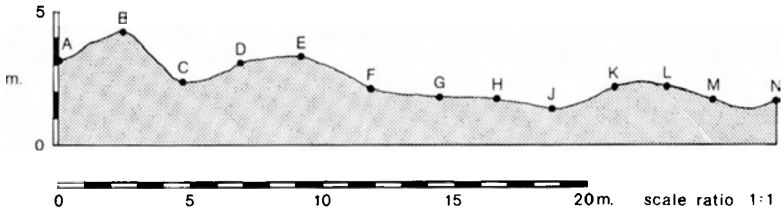
*Fig. 37*




*The Abney level*

This is basically the same as the hand level except that it is capable of measuring vertical angles of altitude and depression. An index arm, on which is engraved a vernier pointer, is attached to the bubble tube. A graduated arc, over which the vernier pointer travels, is fitted to the side of the sighting tube (Fig. 37). The instrument is held in the hand and the staff is sighted at the position whose height is required, by tilting the level. The milled screw which controls the bubble tube is turned until the bubble viewed through the sighting tube is seen to be horizontal, while the cross wire is held on the position. The conjunction of

*Fig. 36*



the vernier pointer and the graduated arc scale is then read to determine the angle of elevation or depression from the horizontal. When taking readings it must be remembered that the angle read on the vernier is equal to the angle the line of sight makes with the horizontal. Therefore, if one is taking a reading from a standing position, the distance between the eye and ground must be allowed for by sighting approximately that distance above the position whose elevation or depression is required. A useful hint is to take the reading by bringing the cross wire into coincidence with the top of the person's head who is holding the staff.

*To read the Abney level.* The vernier pointer has a short scale consisting of a central zero line with six divisions on each side, each representing 10 minutes of arc. The graduated arc scale reads in degrees from 90° elevation to 90° depression. To read the angle sighted the number of whole degrees is read on the graduated arc where it is cut by the central zero line. The parts of a degree, in tens of minutes, are read on the vernier scale forward from the zero index to the line which exactly coincides with a division of the graduated arc scale.

*The clinometer*

The clinometer, whilst not a levelling instrument, is used like the Abney level for measuring ground slopes. It consists of a counter-weighted scale freely suspended in a small metal box so that the line *OX* (Fig. 38) is always horizontal. It is calibrated in both degrees of slope and percentage of slope and both scales are graduated from 0 in both elevation (+) and depression (−). To measure the ground slope along a line *AB*, the surveyor stands at *A* and an assistant stands at *B*. The instrument is sighted, allowing for the distance between the observer's eye and the ground. As the scale is freely suspended, its position in relation to the horizontal will alter and the angle of elevation or depression may be read on the scale from a fixed mark on the clinometer case.

## Contours

### GRIDDING AND CONTOURING

If it is necessary to show ground relief over a larger area than that shown by sections alone, contours should be drawn. As contours are lines joining points of the same height many spot heights will be required of a given area to enable contours to be drawn on the plan with accuracy. The number of spot heights required will vary according to the relief being depicted; as a rule fewer spot heights will be required the more even the slope.

The easiest method of obtaining the spot heights is by grid levelling, which comprises three operations. First: lay out a grid on the ground to be surveyed. Second: obtain spot heights at the grid intersections by levelling. Third: draw the contours on the plan.

(1) *Laying out a grid*

There are a number of ways that a grid may be layed out but the essential points are that the pattern is regular, that it is simple to mark out on the ground, and that it is easy to plot later on the drawing board.

To lay out a grid, mark out a quadrilateral enclosing the site with ranging poles and plot them in when the rest of the detail is being surveyed. Fig. 39 shows a quadrilateral enclosing a site marked by ranging poles *A, B, C,* and *D*. The two opposite sides *AD* and *BC* are measured and are found to be 154 m and 110 m respectively. It is convenient with these measurements to divide *AD* into 11 units of 14 m each and *BC* into 11 units of 10 m each. These subdivisions are then measured off and marked with pegs. Along each of the lines joining the pegs on *AD* and *BC*, intervals of, say, 10 m are measured and the points resulting are the positions of the spot heights. For ease of booking the spot heights, lower-case letters are given to the vertical lines (omitting i and o) and figures to the distance along the lines. A spot height is booked by entering the grid reference, say e50, and then writing the height beside it.

(2) *Taking the height*

This is usually done with the level. If it is possible a level position is chosen from which all the spot heights may be taken and the procedure is similar to that described for levelling a section. In the case where the site being surveyed is large or visibility is obstructed (and the staff difficult to read) it will be necessary to set the level up in two or more positions as described on page 51.

(3) *Drawing the contours*

This is done by direct interpolation. The grid is drawn lightly over the plan and the spot heights are written against the intersections. A convenient vertical interval for the contours is decided on depending on the amount of detail required. If for example in Fig. 40 an interval of 1 metre is to be shown, it can be seen that the 22 m contour cuts approximately one-third of the way between the 21.68 and the 22.73 spot heights and midway between the 21.68 and the 22.23. Ticks are made in these positions and the contours drawn through them. When all contour lines have been interpolated they are then checked for accuracy and then smoothed out before being finally inked in *lightly* on the plan. It is advisable to do the initial drawing work on a tracing paper overlay to avoid making a mess of the plan.

*Fig. 38*

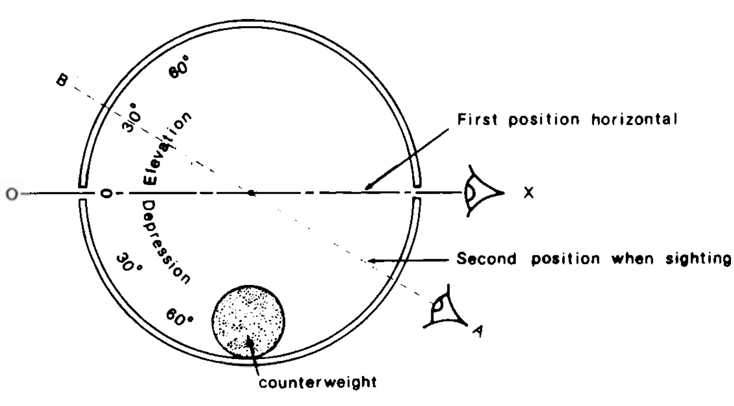



*Fig. 39*

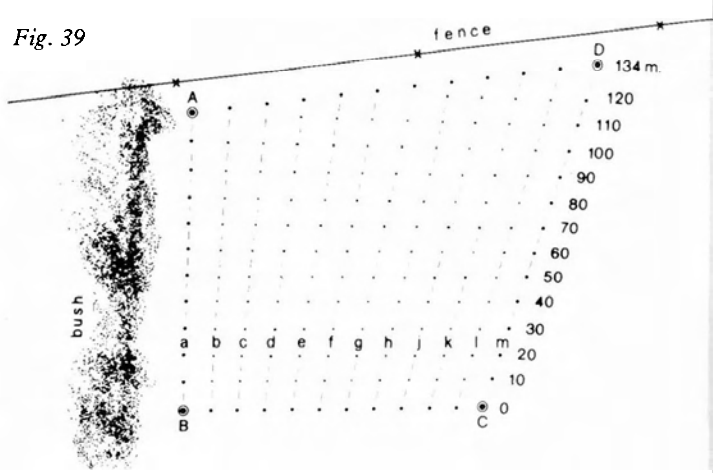


*Fig. 40*

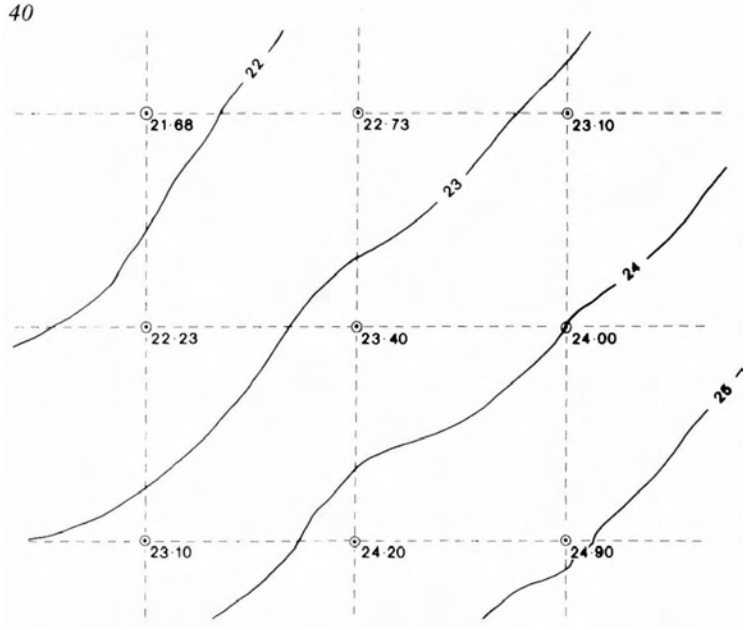
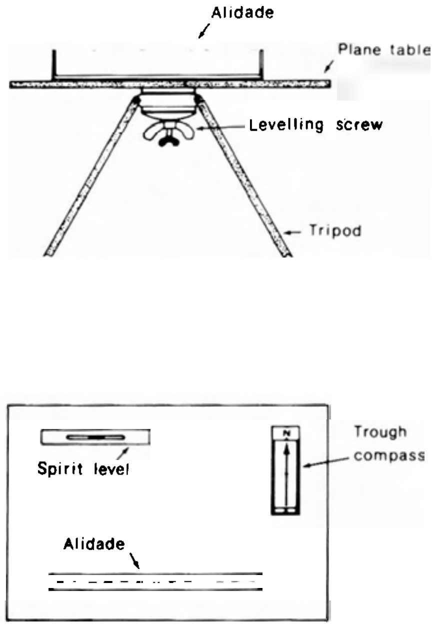



*Fig. 41*




## SURVEY OF LARGE SITES

### The plane table

If a plan of a large area or site is required the plane table is often a more convenient method to make the survey than the methods described previously. It has the advantage that the plan is compiled on the site while work progresses, and not after leaving the area.

THE PLANE TABLE AND ITS ACCESSORIES

The plane table is a drawing board covered with paper which is mounted horizontally on a tripod (Fig. 41).

THE TRIPOD

These are generally of two types: the rigid-leg type and the telescopic-leg type. The essential point is that the tripod is rigid when set up. Care should be taken to make sure that the legs of telescopic tripods are securely fixed when setting up and that the wing nuts attaching the legs to the tripod head are secure.

THE BOARD

Boards come in many different sizes but 450 mm × 600 mm and 450 mm × 450 mm are the most common sizes. The board attaches to the tripod head by means of the threaded socket on its underside.

THE ALIDADE OR SIGHTING RULER

Alidades are made in a number of patterns; the simplest form consists of a boxwood ruler which has a sighting vane mounted on each end. The rear vane (at the sighting end) has a narrow vertical slit and the front vane has a wider slit with a vertical wire stretched down its middle.

Useful refinements to the alidade are a parallel ruler attached to one side, to allow an observed ray to be transferred exactly to or from the point of observation, and a spirit level which is used for setting the table horizontal. Having the spirit level mounted on the alidade prevents it from being mislaid.

*Fig. 42*



#### TELESCOPIC ALIDADE

This type of alidade is the most convenient to use when long sights are involved. It also enables slopes, heights and tacheometric distances to be measured, since the telescope is fitted with a vertical arc and stadia hairs (see p. 60).

#### ACCESSORIES

If a telescopic alidade is not being used and heights are to be determined without recourse to levelling, an Indian clinometer (p. 59) or Abney level (p. 53) must be used, and if the alidade is not graduated a scale ruler is required. Other items, which are not essential but make surveying easier, are a spirit level for levelling the table, a trough compass for orienting the table, a waterproof cover for the table, binoculars, and a notebook for recording rough notes so as not to clutter the survey plan with extraneous figures and lines.

The paper to be used on the plane table should be hard and of a quality to avoid distortion through dampness and atmospheric humidity; a good quality rag-based paper is recommended. The paper should be secured to the table with either paste, drawing pins, or tape. If pins or tape are used they should be placed on the sides or underside of the table so that nothing projects from the upper surface which may impede the alidade as it is moved about to sight desired objects. The paper *must* be taut and immovable on the table.

#### SETTING UP THE PLANE TABLE

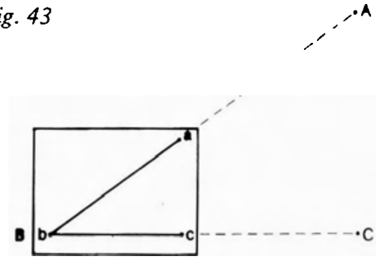
Set up the plane table so that it is at a convenient height (about elbow level) making sure that the tripod has enough spread on the legs to be firm and stable.

Three requirements must be met before commencing the survey.

(1) The table must be *centred exactly* over the station marker. For scales smaller than 1 : 1250 the requirement is satisfied if any part of the table is over the point. For larger scales, however, it is necessary that the point on the plan is centred or plumbed vertically over the corresponding station marker.

(2) The table must be *levelled* by either levelling screws or ball and socket attachment; if these are not fitted, then by manipulating the tripod legs. The table is tested for level in two directions with a spirit level; if one is not available then the table should be levelled by eye and tested for level in two directions by seeing if a round pencil will roll on it or not.

*Fig. 43*




(3) The table must be *oriented* so that a line joining two points on the table is parallel to the corresponding line joining two points on the ground. This may be achieved by two methods. The first method is as follows. The table is centred over station marker *A* (Fig. 43) and levelled. Point *a* is marked off on the plan and station *B* sighted with the alidade. A line *ab* is drawn towards station *B*, the distance *AB* is measured then plotted at a scale suitable for the size of the table, and point *b* marked off on the plan. The table is then moved and centred over station *B* and levelled. The table is oriented by placing the alidade along the line *ba*, then loosening the screw that holds the table to the tripod and gently rotating the table until station *A* is sighted through the alidade. This brings line *ba* parallel with *BA*, the table is then clamped into this position by tightening the screw. Further sights (to station *C*) are now ready to be made.

The second method of orienting the table is to use a trough compass, which is a compass needle contained in a long narrow box. With the table centred and levelled over station *A*, the trough compass is placed on the table and moved until the needle is floating centrally (make sure the needle is unlocked by means of a small button on the side of the box). A line is then drawn along the side of the box. When the table is moved to any other station the table is oriented by placing the trough compass against the line and rotating the table until the needle floats centrally. This method is not as accurate as sighting the preceding station but is a useful means of setting up the table rapidly before making the final adjustment by sighting.

#### THE TECHNIQUE OF PLANE TABLING

Pencils used for plane tabling should be fairly hard, 2H or 3H, and of good quality. When using the alidade make sure that the ruling edge is in contact with the exact point on the table from, or to, which the line is being drawn. In the case of an alidade with a parallel moveable arm, however, it is not necessary for the ruling edge to be in contact with the exact point on the table, as the arm is brought across to the point when the ray is being drawn.

When sighting the alidade it should be pivoted about a finger tip or the blunt end of the pencil. Never pivot about the point of the pencil or a hole will be torn in the paper, obliterating the mark.

Keep the pencil vertical when drawing the rays and draw only that portion of the ray that is necessary for intersection or radiation. If the complete rays were drawn for every point plotted, the plan would become lost in a mass of intersecting lines.

*Caution.* When making sights take care not to upset the table by leaning on it or kicking a tripod leg.

#### FIELDWORK PRIOR TO MAKING A PLANE TABLE SURVEY

Before beginning the survey it is necessary to determine the approximate size and shape of the area to be included on the plan. This is most easily done by pacing. The size and shape of the area together with the size of the plane table will determine the scale at which the plan will be plotted (see pp. 43–44).

At this stage it is necessary to determine the major survey stations. These are chosen so as to cover as much site detail as possible, and where a change of boundary occurs, or where any important feature exists. These are marked with wooden pegs to allow the table to straddle them. Stations to which sights are to be taken are marked with ranging rods plumbed vertically.

As in a chain survey the framework is fixed first by plotting only the main features of the area. The detail is then plotted in by direct measurement from sight stations using offsets (the best method), triangulation, estimation by eye, or by further plane table sights from reoccupied survey stations.

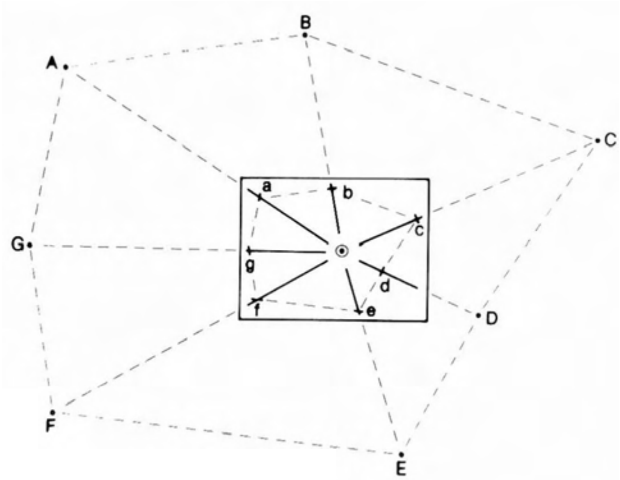
#### METHODS OF SURVEYING WITH THE PLANE TABLE

There are four methods used in plane table surveying: radiation, intersection, traversing, resection.

### *Radiation*

This method relies on being able to find a vantage point from which each sight station is visible (point *O* in Fig. 44). If this

*Fig. 44*




condition can be satisfied, then radiation is a useful and accurate method to use. The plane table is centred, levelled and clamped in a commanding position in the middle of the site. The trough compass is positioned with the needle floating centrally and a line drawn to indicate orientation. A point is marked in the middle of the table to represent the main station *O*, and radiating lines are drawn to all the selected points. The distance is then measured from the table to these positions and scaled off along the rays at the desired scale. The points are then joined up and any further detail required is added by direct measurement from sight stations, by estimation or by further radiation.

### *Intersection*

This is possibly the best method for the archaeologist. It has the advantage that only one measurement on the ground is required, allowing the plan to be completed rapidly by one person, and it is relatively accurate.

In Fig. 45, *A* and *B* are two survey stations chosen so that every sight station is seen from both positions. The distance between *A* and *B* is measured by tape and this distance is scaled off on the table as *ab*. The table is set up with *a* centred, or plumbed, over the survey station *A*. Then the table is oriented onto *B* by placing the alidade along the line *ab*, unclamping the table and rotating it until a ranging rod, vertically erected at survey station *B*, cuts the line of sight. The table is clamped and rays are drawn toward sight stations marking salient features. Only that portion of the ray near the presumed intersections need be drawn. The table is then moved and set up over survey station *B* and oriented back onto survey station *A*, sighting the alidade along the line *ba*. Rays are then drawn from *B* to the same sight stations. The intersections of these rays with the rays drawn previously from *A* locate the various positions of the sight stations and produce the primary framework of the plan. If the intersections intersect at an angle less than 30° or greater than 150° the error introduced will make the position of a point on the plan extremely unreliable. To overcome this a third survey station is established to provide a check on the intersection from the other two.

On certain sites it will not be possible to see the whole area from one single vantage point, in this case both the radiation and intersection methods are combined.

Three points *A*, *B*, and *C* are chosen in a straight line. The distances apart of the points are carefully measured by tape, the corresponding points *a*, *b* and *c* are plotted to the required scale on the table. The table is set up over *A* and oriented onto *B*. From *A* in area 1 (Fig. 46) all accessible detail is plotted by radiation, as is also done from *B* in area 2, and *C* in area 3. The more inaccessible detail is plotted by intersection from *A*, *B* and *C*. Whenever possible draw three intersecting rays as a check. A position is correctly located when the three rays meet in a point. If they do not, a small triangle will be created and it is then up to the surveyor to decide whether the error is acceptable or not at the scale being used. If the error is acceptable (i.e., assuming the point lies within the triangle) the error is halved by placing the point in a central position within the triangle.

*Fig. 45*

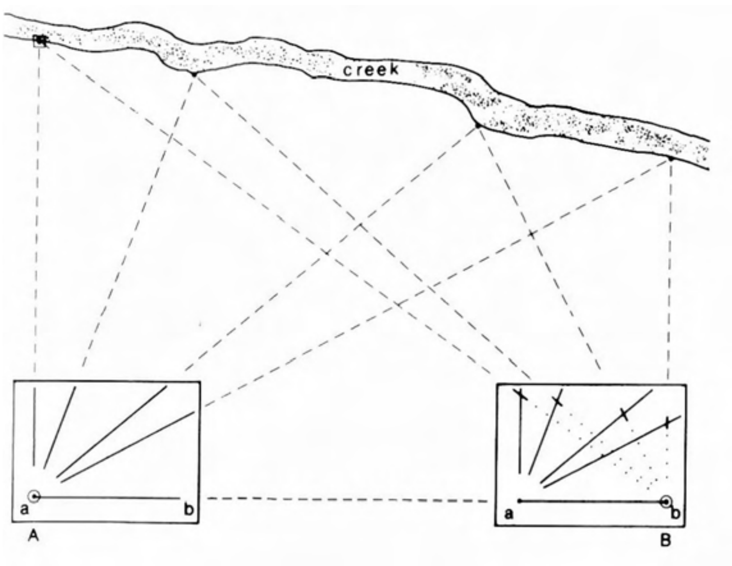



*Fig. 46*

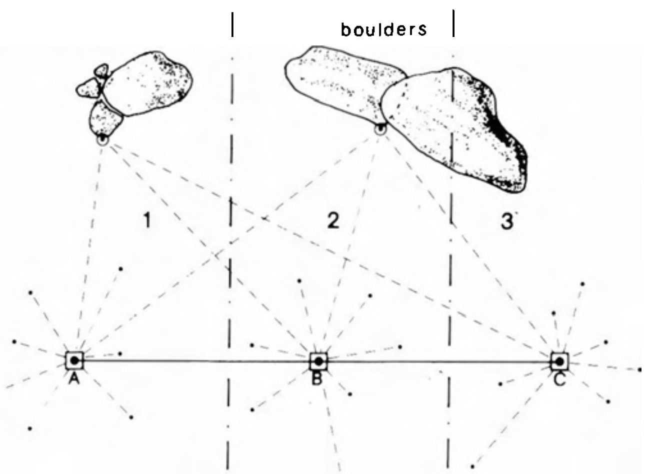
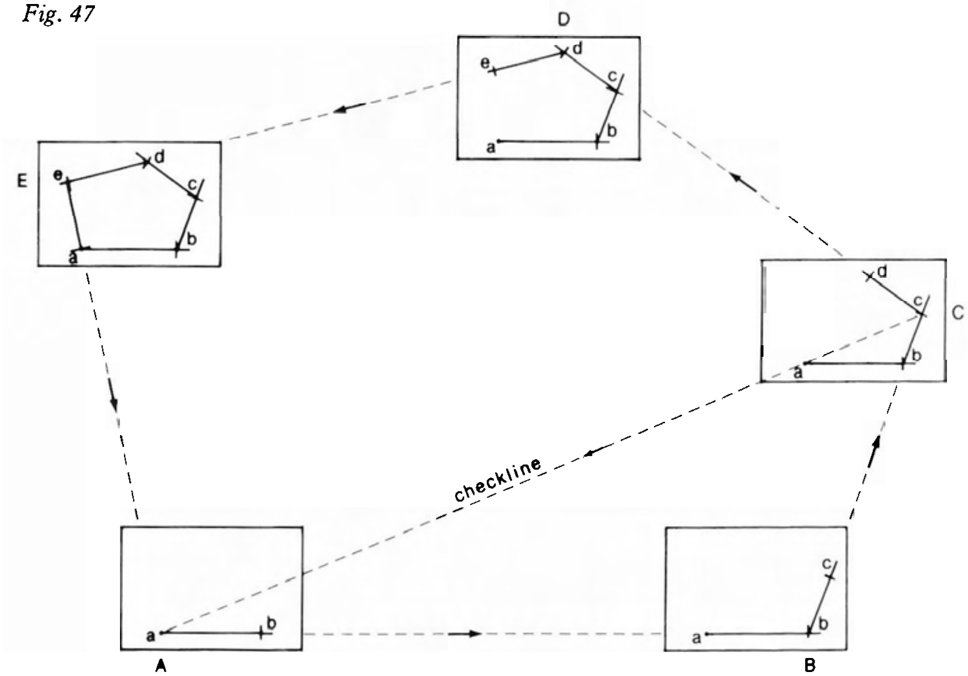


*Fig. 47*




The traverse is closed using the following method (Fig. 48):

(1) Join points $A$ and $a^1$ on the plan and draw short lines parallel to $a^1A$ through $b, c, d, e$.

(2) Draw a line and set off to scale on it the distances $Ab, bc, cd, de$, and $ea^1$.

(3) Erect short perpendiculars at $b, c, d, e$, making the last $a^1A$ equal in length to the closing error of the traverse.

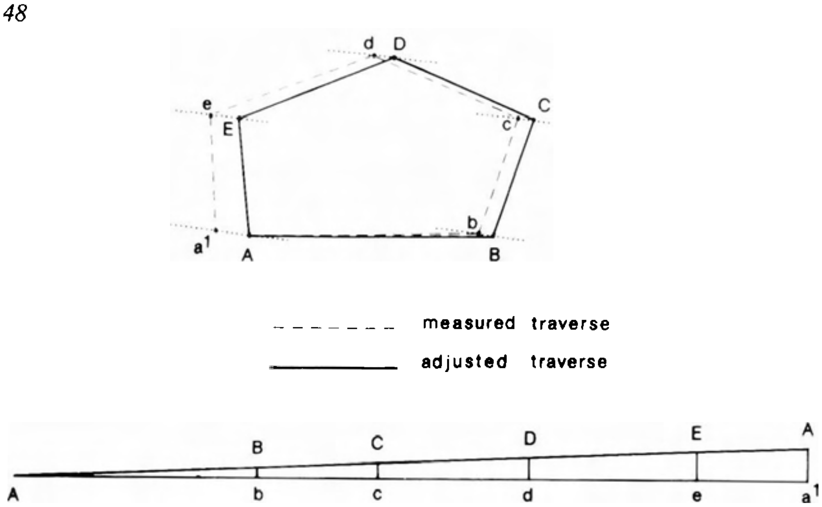
(4) Join the two points $AA$. The resulting lengths of the short perpendiculars $bB, cC, dD, eE$ give the distance that each of the plotted survey stations $a, b, c, d, e$, and $a^1$ must be moved along the short parallel lines drawn on the plan, to adjust the position of the survey stations to close the traverse. It is important to note that any detail plotted from the original survey stations must be replotted from the new, adjusted positions.

*Traversing*

This method of plane table surveying is not often used in archaeological work but may be useful if vision is obscured by large trees or rocks, etc. The survey stations are selected on the ground and marked with pegs. A point is arbitrarily marked on the table from which the traverse will be started, $A$ and $a$ in Fig. 47. The table is centred and levelled over survey station $A$ and oriented either with the trough compass or arbitrarily. Survey station $B$ is sighted with the alidade and a ray drawn towards it. The distance $AB$ on the ground is measured and $b$ marked off at the required scale along the ray. The table is then set up over $B$ and oriented back onto $A$. Survey station $C$ is sighted, $BC$-measured and $c$ marked off on the table. This procedure is repeated at survey stations $C$, $D$ and $E$, taking checks where possible by sighting cross rays such as $CA$. Detail surrounding each survey station is plotted in by radiation, intersection or direct measurement as the survey progresses.

The final check on the accuracy of the traverse is how closely it closes on the starting point $A$. Usually the traverse will not close exactly, returning instead to a point $a^1$.

*Fig. 48*




*Resection*

This method is used only for the location or relocation of survey stations. During a plane table survey it is sometimes necessary to plot a position in the survey area which has not already been surveyed in by radiation or intersection. In this case the positioning of the new survey station will depend on having three sight stations already planned. The table is set up on the new survey station desired, it is levelled, oriented with the trough compass and clamped. The alidade is positioned against one of the former sight stations on the plan and sights aligned onto the corresponding position on the ground. A ray is drawn from the sight station to the new survey station $C$. The alidade is then sighted onto the second sight station shown on the plan and the process is repeated and similarly with the third sight station. The three rays drawn back from the sight stations towards the new survey station $C$, should intersect at the same point. If they do not they will form a triangle of error, the centre of which is accepted as the position of station $C$. If the error is considered too great the table can be reoriented to the left or right and the entire process repeated until the triangle is reduced to a point. Once survey station $C$ is plotted satisfactorily check-sightings should be made to one or more sight stations already plotted. From the new survey station $C$ a new survey station $D$ can then be sighted, forming a new base line $cd$ from which any new features may be sighted (Fig. 49).

*Fig. 49*

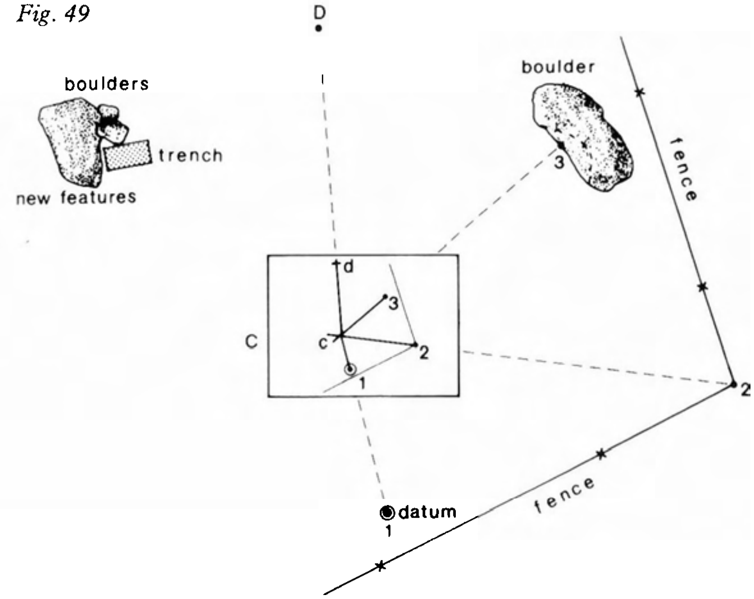



*Fig. 50*

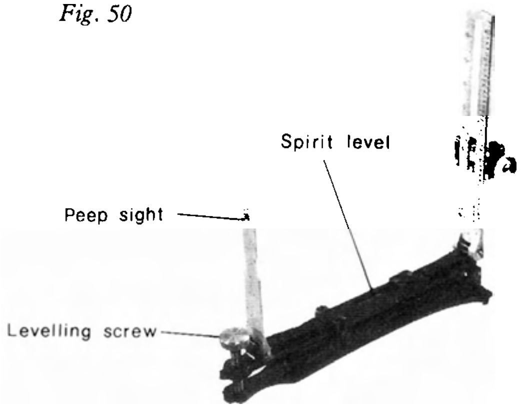
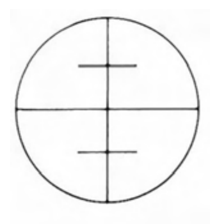



*Fig. 51*



*Fig. 52*



MEASUREMENT OF HEIGHTS

When making a plane table survey, spot heights may be measured by use of the level, the Indian clinometer, or the telescopic alidade. The use of the level has already been described (pp. 48–54); that of the other instruments is given below.

*The Indian clinometer*

This instrument is designed mainly for use with the plane table, to determine spot heights. The Indian clinometer consists of a moveable base with two vertical sights. To measure the height of an object the clinometer is set on the table and sighted towards the object. The base is then levelled using the levelling screw and the spirit level. With the base levelled, look through the rear circular 'peep' sight at the object and move the horizontal wire on the front sight up or down, using the control wheel at the side, until the wire cuts the object. Then on the front sight, beside the wire, the tangent of the angle of elevation or depression is read. This is multiplied by the horizontal distance between the plane table and the object to find the difference of height between the *surface of the table* and the object. It is important to check the base bar for horizontality before each sight. Also, care must be taken to read the correct scale, as two scales are engraved on the front sight, the tangent scale and the angle scale in degrees (Fig. 50).

*Telescopic alidade*

The telescopic alidade used in conjunction with a graduated staff can greatly reduce the time taken when making a plane table survey by the radiation method. It has the advantage that heights, distances and degree of slope may all be measured at each sighting (Fig. 51).

To take heights with the telescopic alidade, place the instrument on the table; check that the pillar is vertical by means of the small transverse spirit level and adjust with the large wheel at the base of the pillar (some instruments do not have this facility). Zero the graduated arc by unclamping the telescope, setting the scale to zero and reclamping. Level the telescope by turning the knurled knob on the pillar under the telescope until the bubble of the large spirit level beside the telescope is central. With the instrument levelled, sight a graduated staff placed on the object whose height is required. Read the measurement where the horizontal cross hair cuts the graduated staff. This gives the difference in height between the object and the telescope.

Like the level, the alidade telescope has two main cross hairs with which to sight the object and two short stadia hairs above and below the main horizontal cross hair (Fig. 52). These stadia hairs are used to measure the distance of an object from the alidade, by tacheometry.

To measure distances tacheometrically the radiation method is used. An assistant holds the graduated staff at every point which is to be plotted and the observer at the plane table reads the staff where it is cut by both the upper and lower stadia hairs, e.g., 1.53 and 0.69. The difference between these two readings is multiplied by 100 which gives the distance of the staff from the alidade, e.g., $1.53 - 0.69 = 0.84 \times 100 = 84$ m. The above process is, however, only accurate for horizontal lines of sight.

*Sloping sights* (Fig. 53).

When the line of sight is sloping, the vertical arc fitted to the alidade is used in conjunction with the stadia hairs to calculate the true horizontal distance ($H$) between the alidade and the object. For alidades with vertical arcs calibrated only in degrees, the true horizontal distance is obtained by multiplying the difference of the two stadia readings ($S$) by 100 and then

by the cosine squared of the angle made by the line of sight with the horizontal. Thus, $H = 100\ S\ \mathrm{Cos}^2\theta$. If the angle of slope does not exceed 3° (1 in 20) it is not necessary to use the cosine squared of the angle $\theta$.

The difference of height between the alidade and the object ($V$) may also be calculated at the same time as the distance. This is done by multiplying the difference between the stadia hairs ($S$) by 100, and then multiplying it by the cosine and sine of the angle $\theta$, minus the height of the position on the staff cut by the centre cross hair ($h$). Thus, $V = 100\ S\ \mathrm{Cos}\theta\ \mathrm{sine}\theta - h$.

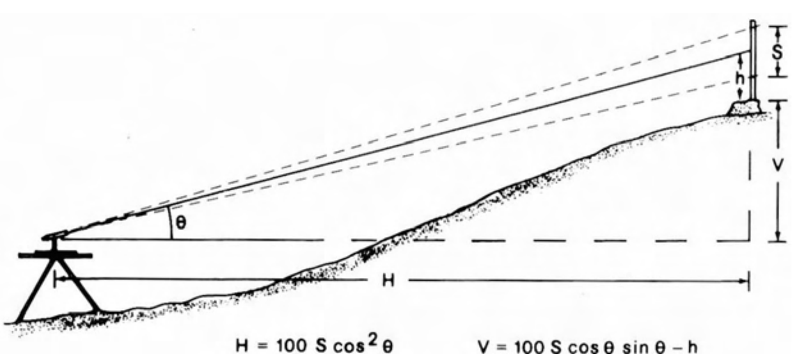
*Beaman stadia arc*

On most modern alidades the vertical arc of the telescope is fitted with a Beaman stadia arc in addition to plain degree graduations. This configuration greatly simplifies the calculations described above. The Beaman stadia arc consists of two scales, $H$ and $V$, which are read instead of the angle $\theta$ in degrees. The $H$ scale gives a value for correcting the horizontal distance obtained using the $100 \times S$ formula. The $V$ scale gives a factor which, when multiplied by $S$, gives the difference in height between the alidade and the staff reading cut by the centre cross hair.

*Method of observation.* Make sure that the bubble of the spirit level beside the telescope is in its central position, sight the staff held on the object, read the staff graduations cut by the upper and lower stadia hairs to obtain $S$. Then read the staff graduation cut by the centre cross hair to obtain $h$; next read the $H$ and $V$ scales of the Beaman arc. The horizontal distance is calculated from $100 \times S - H$ scale reading $\times S$. The difference in height is calculated from $S \times V$ scale reading $- h$.

If the vertical arc of the telescope is graduated only in degrees, the table below gives the various $H$ and $V$ values corresponding to degrees.

*Fig. 53*




Beaman stadia arc: $H$ and $V$ readings for difference value of $\theta$.

| $\theta$° | $H$ | $V$ | $\theta$° | $H$ | $V$ |
|---|---|---|---|---|---|
| 1 | 0.03 | 1.74 | 13 | 5.06 | 21.92 |
| 2 | 0.12 | 3.49 | 14 | 5.85 | 23.47 |
| 3 | 0.28 | 5.23 | 15 | 6.70 | 25.00 |
| 4 | 0.49 | 6.96 | 16 | 7.60 | 26.50 |
| 5 | 0.76 | 8.68 | 17 | 8.55 | 27.96 |
| 6 | 1.09 | 10.40 | 18 | 9.55 | 29.39 |
| 7 | 1.48 | 12.10 | 19 | 10.60 | 30.78 |
| 8 | 1.94 | 13.78 | 20 | 11.70 | 32.14 |
| 9 | 2.45 | 15.45 | 21 | 12.84 | 33.46 |
| 10 | 3.02 | 17.10 | 22 | 14.03 | 34.73 |
| 11 | 3.64 | 18.73 | 23 | 15.27 | 35.97 |
| 12 | 4.32 | 20.34 | 24 | 16.54 | 37.16 |

*Example calculation*
line of sight elevated 12°
stadia hairs, 0.69 and 1.53
($S = 0.84$) Beaman arc, $H$ scale 4.32
centre hair 0.92 ($h = 0.92$) $V$ scale 20.34
horizontal distance $= (100 \times 0.84) - (4.32 \times 0.84) = 84 - 3.62 = 80.38$ m
difference in height $= (0.84 \times 20.34) - 0.92 = 17.08 - 0.92 = 16.16$ m

## APPENDIX 1

### Cosines for degrees of slope

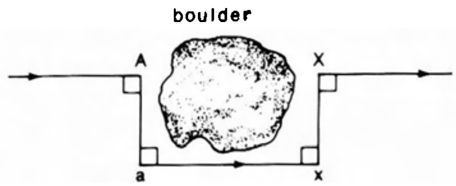
| | | | | | |
|---|---|---|---|---|---|
| 1° | .9998 | 16° | .9613 | 31° | .8572 |
| 2° | .9994 | 17° | .9563 | 32° | .8480 |
| 3° | .9986 | 18° | .9511 | 33° | .8387 |
| 4° | .9976 | 19° | .9455 | 34° | .8290 |
| 5° | .9962 | 20° | .9397 | 35° | .8192 |
| 6° | .9945 | 21° | .9336 | 36° | .8090 |
| 7° | .9925 | 22° | .9272 | 37° | .7986 |
| 8° | .9903 | 23° | .9205 | 38° | .7880 |
| 9° | .9877 | 24° | .9135 | 39° | .7771 |
| 10° | .9848 | 25° | .9063 | 40° | .7660 |
| 11° | .9816 | 26° | .8988 | 41° | .7547 |
| 12° | .9781 | 27° | .8910 | 42° | .7431 |
| 13° | .9744 | 28° | .8829 | 43° | .7314 |
| 14° | .9703 | 29° | .8746 | 44° | .7193 |
| 15° | .9659 | 30° | .8660 | 45° | .7071 |

## APPENDIX 2

### Methods of sidestepping obstacles

In Fig. 54 the measurement is taken up to the obstruction at point $A$, where a right angle is set out and a line is measured along this perpendicular to $a$. At point $a$ another right angle is set out and the measurement continued to point $x$, which is situated in a position clear of the obstacle which will allow a further right angle to be set out. Measure a distance equal to $Aa$ along this perpendicular, to $X$. Another right angle is set out and the measurement of the original line is then resumed. The length of line $ax$ is equal to the unmeasured distance $AX$. The only check on this method is to see if the resumed line does point to the destination. If the sidestep around an obstacle is a long one, it is safer to use a slightly different method as is shown in Fig. 55.

*Fig. 54*




Right angles are set out at points $A$ and $B$ and measurements made to $a$ and $b$ so that $Aa$ equals $Bb$. The measurement is then continued along the line $ab$ which is produced to $y$ and $x$. Right angles are set out at these points and measurements made to $Y$ and $X$ so that $Yy$ and $Xx$ are both equal to $Aa$. The main line is then resumed along $YX$. This method provides partial checks by $ab$ being found to equal $AB$, and $YX$ to equal $yx$. The distances $AB$ and $yx$ should approximate the distance $BY$, but they should not be less than 15 m regardless of the extent of the obstacle.

A method employing identical triangles can be used to sidestep obstacles, provided a ranging rod may be sighted over or through them. This method has the advantage that it is usually more convenient to use and has less chance of error than the above method.

To measure the distance $BC$, place ranging rods at $A$ and $B$ and then range in a rod at $C$ creating a straight line $ABC$. At any convenient point $D$, which clears the obstacle and from which $B$ and $C$ can be sighted, place another ranging rod. Range in point $a$ by sighting from $C$ through $D$ and point $b$ by sighting from $B$ through $D$ respectively, making the lines $bD$ and $DB$, $aD$ and $DC$ equal in length. Because triangles $BCD$ and $abD$ are identical the

*Fig. 55*

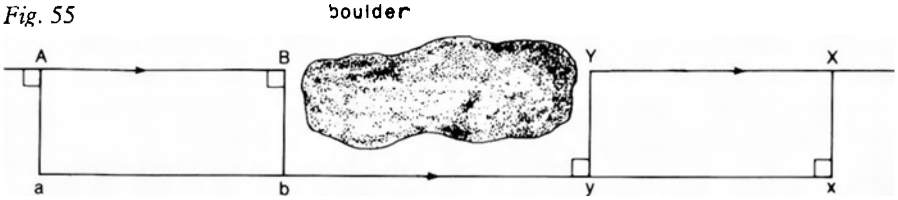



*Fig. 56*

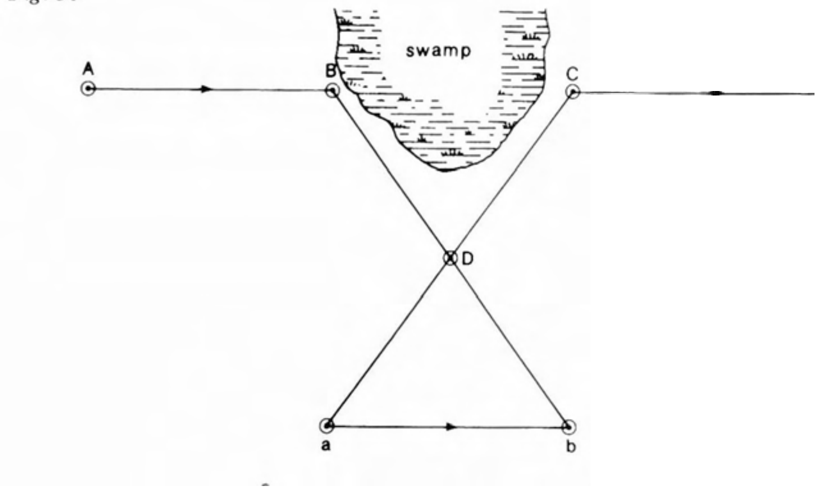



*Fig. 57*

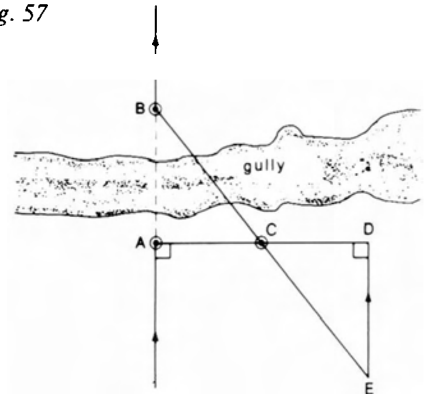
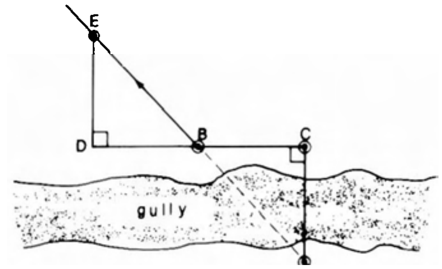



*Fig. 58*




length of *ab* equals the length of the unknown *BC* (Fig. 56).

If a traverse line crosses a creek or a sudden undulation such as a gully, there are two convenient methods to find the distance between two points on either side.

(a) *Traverse line at right angles to obstacle*

Set up ranging rods at *A* and *B* on the traverse line. Set out line *AD* at right angles to the traverse line, then set up a ranging rod at *C* so that line *AC* is equal to line *CD*. Set out *DE* at right angles to *AD* and locate *E* so that *ECB* is one straight line. This creates identical triangles where the distance *DE* equals the unknown distance *AB*.

*Fig. 59*

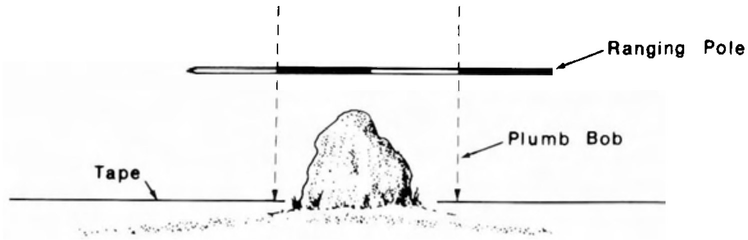
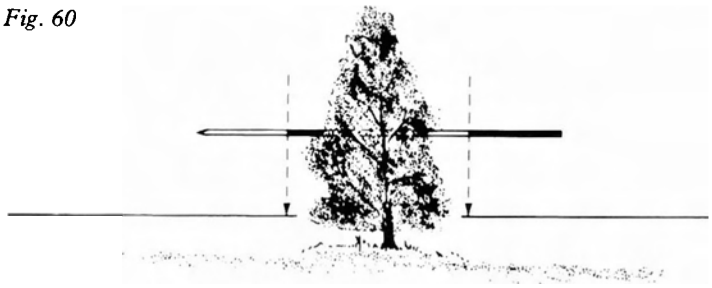



*Fig. 60*



(b) *Traverse line crossing obstacles obliquely*

Set ranging rods at *A* and *B*; using an optical square range in point *C*; extend line *BC* to *D*, so that *BC* equals *DB*. Using the optical square range in point *E*. The distance measured between *B* and *E* equals the unknown distance *AB* (Fig. 58).

Small obstacles in chaining a line can often be overcome by using a ranging rod to provide a horizontal measurement which is plumbed on to the steel band or tape.

When surveying it is convenient to fix the main stations to avoid major obstacles, however in a large survey topography often prevents visibility from one end of the line to the other. In Fig. 61 *A* and *B* have their line of sight cut by a low hill. To range in a straight line between these two points, two people *C* and *D* take a ranging rod each and place themselves on the hill so that each can see both *A* and *B*. *C* stands as nearly as possible as can be judged in the line *AB*, and positions *D* to stand exactly in line with *B*. In this position $D_1$, *D* sees that $C_1$ is out of line with *A* and so moves him to $C_2$; *C*

*Fig. 61*

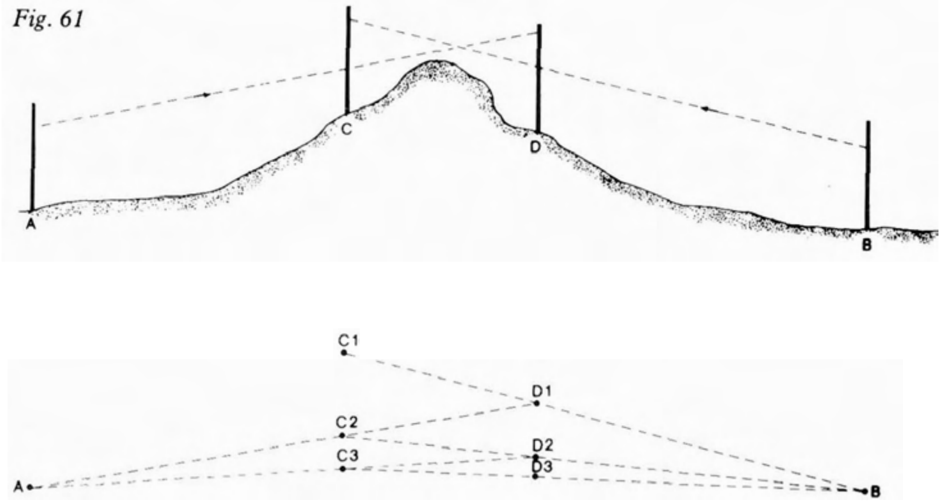



*Fig. 62*

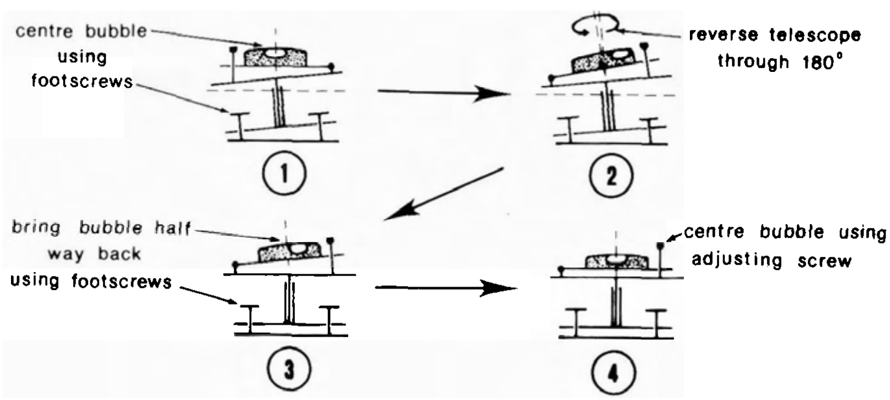
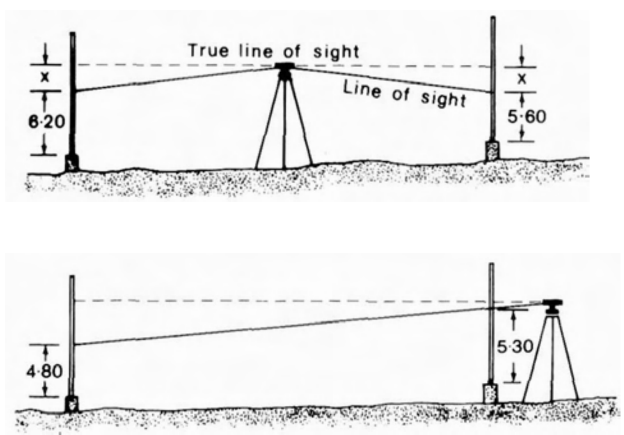



*Fig. 63*




then moves $D$ to $D_2$ and so on until both $C$ and $D$ are exactly in line with $AB$.

## APPENDIX 3

### Permanent adjustments to level

An adjustment to the instrument should only be made when the instrumental error is of such a magnitude that it will affect the accuracy of the observations. There are two adjustments that may be made to a level. The first is to set the tubular bubble axis at right angles to the vertical axis of the instrument, and the second is to set the line of sight of the telescope at right angles to the vertical axis of the instrument.

*Adjustment No. 1: setting the bubble axis at right angles to the vertical axis*

Set up and level the instrument. Turn the telescope over a pair of footscrews and centre the bubble exactly. Then reverse the telescope (turn through 180°). If the bubble runs off centre, bring it halfway back with the footscrews and the remainder of the way with the adjusting screw on the bubble tube (Fig. 62).

*Adjustment No. 2: setting the line of sight of the telescope at right angles to the vertical axis (Fig. 63).*

(1) Set the level up midway between two pegs 90–120 m apart. Hold the staff on one peg and note reading, say, 5.60.

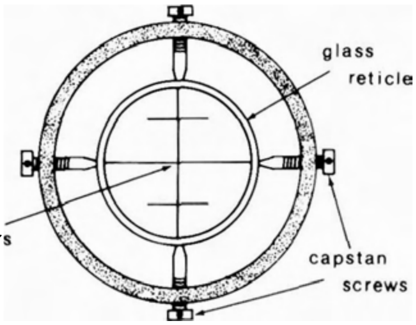
(2) Place the staff on the second peg and note the reading, say, 6.20. The difference in height of the pegs is 6.20 − 5.60 = 0.60. This value will be correct even though the instrument may be out of adjustment, as the level is midway between the two points and the error in staff reading will be the same for each point.

(3) Move the instrument close to one peg and again read the heights for both points, and obtain the difference in height 5.30 − 4.80 = 0.50. This is not the same as the true difference in height (0.60) and thus the instrument is in error by 0.10 over the distance.

(4) To adjust the error, the correct reading for the far staff must be calculated. As the error on the near staff is very small, this reading (5.30) is accepted and the value (0.60) for the true difference in height is added to it, 5.30 + 0.60 = 5.90.

(5) With *automatic levels and dumpy levels* the eyepiece is unscrewed,

*Fig. 64*




exposing the glass reticle on which the stadia hairs are etched. This is moved by its centering screws until the calculated reading of 5.90 is noted on the far staff, taking care that the bubble is central at the same time.

(6) With *tilting levels* the horizontal hair is set to the calculated reading of 5.90 on the far staff and then the tubular bubble is centred, or the ends of the split bubble are set in coincidence, by turning the bubble adjustment screw.

*Note:* It is only rarely that this particular adjustment is necessary and if at all possible it should be carried out by an instrument maker or trained surveyor.

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*Note:* Chapter submitted in 1980.

# Chapter 5

# Terrestrial photogrammetry in Australian archaeology

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Along with our increasing awareness of the complexities of field data has come an obligation that we record and describe to the best of our abilities the range of data which we have discovered. Normally we are frustrated in our attempts to achieve this because the number of possible measurements and observations we could make on even a simple single site seem endless. This situation is aggravated if the researcher embarks on a study of a complex site or regional survey. While well defined research objectives do much to focus the fieldworker's vision and direct the expenditure of his energies, in some cases there still remains an overwhelming amount of field data which the researcher knows he must record to satisfy his requirements. At times like these it may be necessary for the researcher to call on some powerful technique which may help solve the data collection problem. Photogrammetry is one such aid. It is a precision technique that records spatial information in a way which allows the interpreter to construct a scaled-down model or map a distribution of physical data which might be too difficult to attempt by other means. All archaeologists already use photogrammetric products when they consult topographic maps which are made by aerial photogrammetric procedures. But most archaeologists, usually concerned with mapping small areas such as sites or site features, will find more utility in a branch of photogrammetry that does not require aircraft and is called *terrestrial photogrammetry*.

It cannot be overemphasised that a decision to apply the photogrammetric technique must be carefully considered. By way of a hypothetical example I would like to introduce the reader to a kind of situation which might lead a frustrated archaeologist to seek photogrammetric assistance and then describe the manner and form in which the help might come.

Let us suppose that we have a well intentioned PhD student who has stumbled upon a rich archaeological deposit which is adjacent to a complex rock art gallery. The art gallery is confined to a sandstone cliff face which he observes from below. The depictions, he notices, are primarily of two kinds, bichrome painting and engravings. These together are distributed across 30 metres of cliff face and reach a height of 12 metres above ground level. The paintings were executed on flat surfaces and are still reasonably clear. The engravings were done so as to incorporate aspects of the surface topography as elements of the essential designs, or so he suspects. By rough count he figures there are about 600 individual paintings and about 150 engravings. He would set about to record the art which he suspects contains data that complements information he has gathered from his nearby excavations, but he cannot reach the majority of the art to trace it, the sandstone wall is too friable to allow ladders to be safely placed against it, and he realises that he does not really have time to trace 750 art motifs anyway. He could, he thinks, trace a representative sample but the depictions are all so different that he would not be confident in constructing a sample. And, after all, like everyone else he does not know much about rock art, nor is he sure which of the motifs he will find useful in understanding his site, although he has a vague nagging feeling that the multiplicity of strange-looking large engravings of animal tracks may bear some relationship to his recent excavation of stone projectile points, associated with the bones of 16 extinct marsupial species, all of which he has dated to 100 000 years BP! To make matters somewhat urgent a petrochemical plant is near completion on the mesa above and has received government approval to use the cliff face as a spillway for the discharge of its alkaline effluents. And finally, he has just received notification from his granting agency that next year's budget reductions will require that he exchange his motor vehicle for a bicycle or wheel barrow, his choice. Clearly, something must be done, now!

He decides to contact a surveyor/photogrammetist because he believes a photo record from which he can make an accurate contour map will give him the best survey of the gallery possible in the limited time available to him. Actually, the photogrammetry will be so efficient in producing an overall map that he will have time to make a few drawings, tracings and observations about subtle details of the art assemblage.

After some negotiation a photogrammetist arrives at the site and sets about the following procedures.

(1) He establishes a baseline, parallel to the cliff face, about 14 metres from the cliff, so that the field of view of his camera (about 70°) will take in the full vertical height of the art.

(2) He establishes a second baseline at a distance of 3 metres from the cliff face because the archaeologist wants close-up coverage of one area.

(3) He puts cross-hair targets on nearby tree trunks and on the cliff face. These are his reference marks for all measurements.

(4) He selects seven camera stations along the baselines. These are placed so that he achieves the desired overlap of photographic coverage.

(5) At each of the camera stations in turn he sets up and adjusts a theodolite which has a special camera mounted on top of it. Using the theodolite he takes accurate fixings on each of his targets and with the camera, which is loaded with colour diapositive film, he photographs the cliff face (Fig. 1).

Of course this is a gross oversimplification of each of the steps involved but it should suffice to describe the general field process. Readers who are interested in a full account of the technical details are encouraged to consult Wolf (1974). But by this stage an archaeologist and photo-

grammetist are only half finished. They have theodolite data which give them precise details about the location of their theodolite/camera stations relative to the cross-hair targets which are plainly visible in their diapositive photos of the cliff face. Now it remains for them to use the photos and the theodolite data to make a scaled-down model of the art gallery. For this they must retire to the laboratory and make use of the instrument which will recreate the stereo images encoded on their diapositives.

The primary instrument in the map-making process is the *stereoplotter*. This apparatus (again stripped of its complexities) is one which projects the images contained in the stereo diapositives. It does this in such a way that an operator can view a stereo model of the subject with a small but very important illuminated 'floating dot' superimposed upon it. The operator can at his discretion manipulate three controls (two hand-wheels and one foot-disc) each of which moves the floating dot in one of the three dimensions he is viewing through the binocular eyepiece of the stereoplotter. The mechanical operation of the three controls not only determines the path of the floating dot on the projected model but also operates an articulated illustrating apparatus which recreates the path of the dot as a line drawing on a drafting medium. Because this medium is of course only two-dimensional the operator will first concern himself with tracing the outlines of two-dimensional features in the model, which in our case would be the outlines of the art motifs and visible characteristics of the rock wall, for example, fissures, sedimentary planes and conglomerate features. Then, he can set about moving the floating dot in concentric patterns which closely approximate the third dimension he sees in the stereo model. At the same time the articulated illustrating apparatus will be drawing the course of the dot as contour lines on the same drafting medium, or on a separate sheet for subsequent overlay on the two-dimensional illustration.

There is a range of photogrammetric instruments available from several manufacturers. Cameras range from relatively simple single lens theodolite-mounted types to photo-theodolites which combine the two instruments in a single housing, and to stereometric cameras which consist of two identical cameras mounted in parallel on a fixed base. The latter may be operated simultaneously for maximum freedom from the distortion caused by minor changes in ambient light, which can occur in the few moments it takes to move a single camera to a second station. Plotters are no less variable in manufacturing design or application. They may be fairly straightforward optical/mechanical types, or electronic, automated, computer-coupled and designed to produce a mathematical rather than visual model. Figures 2–4 illustrate a few commonly used and relatively simple instruments.

The discussion of the photogrammetric technique and the description of the instruments, grossly simplified though they are, should make it clear that photogrammetry is not a skill which one could master overnight. Indeed, archaeologists must seek the cooperation of professional surveyor/photogrammetists if they feel that they require the results photogrammetry offers, having assured themselves beforehand that there is no simpler solution. This is not to say that there is little or no scope for photogrammetry in archaeology. Clearly, the contrary has already been demonstrated. In classical archaeology photogrammetry has successfully mapped exposures of walls and floors in Roman and Grecian sites, where photogrammetric

*Fig. 1*
*Terrestrial photogrammetric field set-up, plan view.*

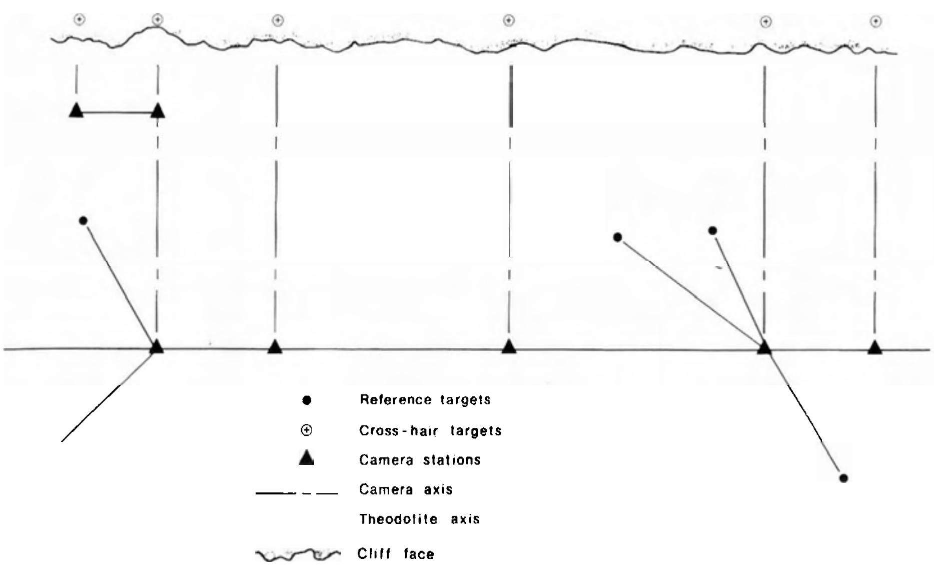
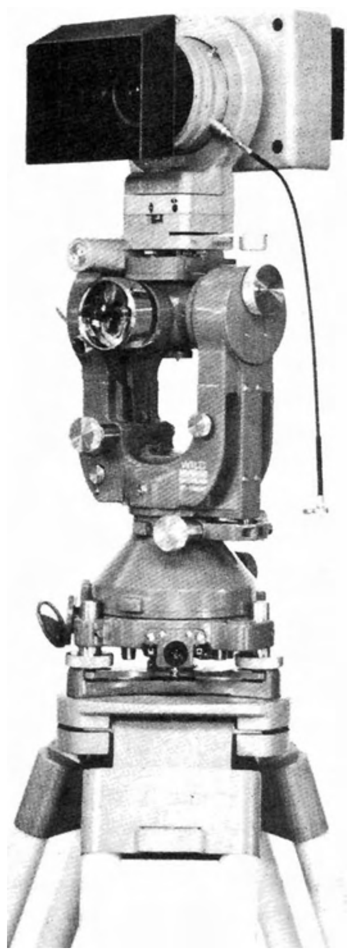



*Fig. 2*
*Wild P32 terrestrial camera mounted on a Wild T2 universal theodolite (by courtesy of Wild Leitz Pty Ltd).*



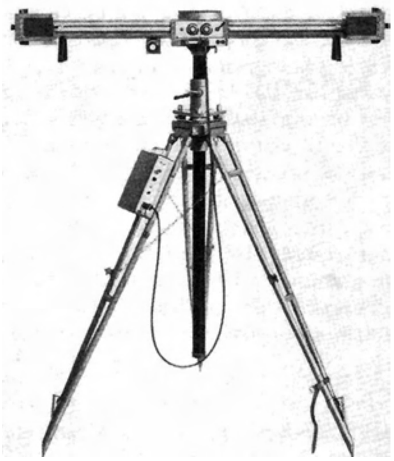


*Fig. 3*
*Wild C120 wide-angle stereometric camera (by courtesy of Wild Leitz Pty Ltd).*

equipment has been ingeniously elevated by means of bipods, tripods, gas-filled balloons and even kites (Whittlesey, 1975). And in the most technology-dependent archaeology of all, underwater archaeology, highly elaborate photogrammetric recording methods have produced detailed maps of *in situ* remains of Roman shipwrecks (Rosencrantz, 1975). Closer to home than these esoteric examples, Neville Clouten (1976, 1977) has made contour maps of Australian rock art sites found in rock shelters (Laura) and on open air surfaces (Mootwingee).

Many uses of photogrammetry in archaeology could fairly be termed experimental. Truly efficient uses of photogrammetry in archaeology have probably not yet been made. But this may be just on the horizon in Australian archaeology. State archaeological services, for instance, have the responsibility for recording and monitoring the preservation status of large numbers of art sites, stone arrangements, and other observable surface features. One can imagine that a single field unit of one or two site recorders, armed with a stereometric camera, could range quite widely and effectively produce a data bank or archive in a manner which would

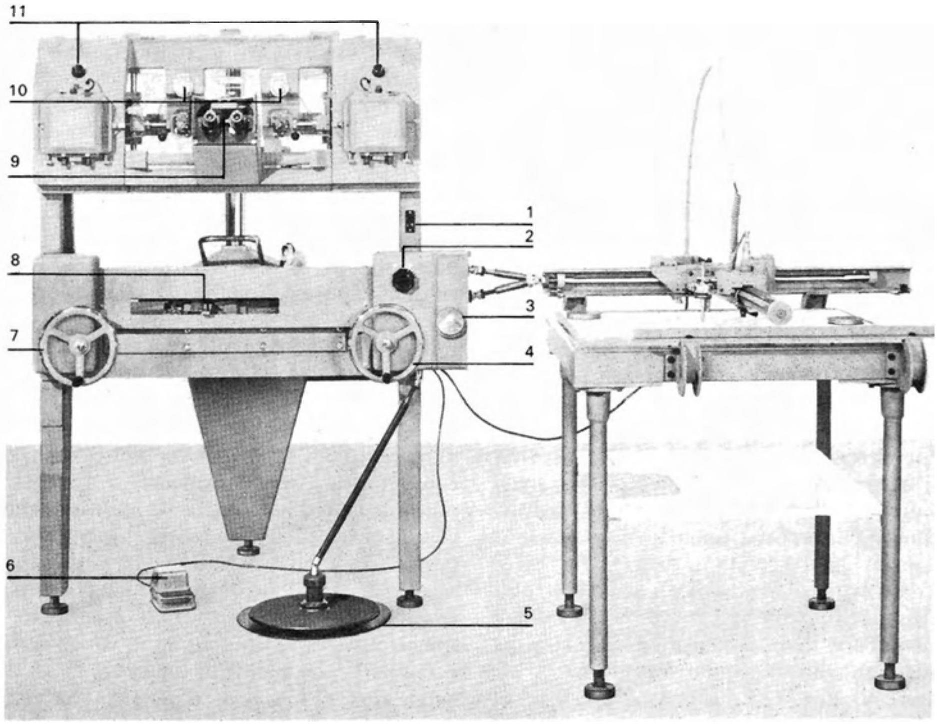



*Fig. 4*
***Wild A40 autograph and plotting apparatus** (by courtesy of Wild Leitz Pty Ltd).*

*(1) Main switch.*
*(2) Y-Z interchange knob.*
*(3) Z-counter.*
*(4) Y-(Z-) handwheel.*
*(5) Footdisc for Z- (Y-) motion.*
*(6) Footswitch for electro-magnetic pencil-filter.*
*(7) X-handwheel.*
*(8) Release lever for free-hand motion of the X-carriage.*
*(9) Ocular box.*
*(10) Principal-distance setting.*
*(11) Variable resistances to vary the illumination of the pictures.*

systematically describe the form and condition of most kinds of sites. The plotting of the stereo-models, of course, need not be done until it becomes necessary, the information being conveniently stored in the diapositive film. Whatever the potential uses of photogrammetry in Australian archaeology may be, their eventual realisation will depend on the carefully reasoned assessment and vision of the field archaeologist.

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*Note:* Chapter submitted in 1980.

# Chapter 6

# Planimetry: scale drawings from photographs

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Scale drawing of rock art surfaces or artefact scatters is time-consuming, biting heavily into limited fieldwork time, particularly in the case of archaeological survey work. This chapter discusses the production of scale drawings using photographs taken with an ordinary camera, allowing the fieldworker to record artwork or artefact scatters rapidly in the field and prepare the diagrams after fieldwork is over.

Beaton (Chapter 5) discusses the technique of photogrammetry, which allows one to make contoured scale drawings of surfaces from stereo photographs. However, photogrammetry is a demanding technique requiring expensive, bulky equipment and considerable expenditure of time, both in the field and in the preparation of the drawings. Most workers will be satisfied with moderately accurate scale drawings without contours, which can be achieved rapidly and easily with an ordinary camera. The latter technique is known as planimetry.

The keys to accuracy in making scale drawings from photographs are (1) to take the photograph at right angles to the surface to be drawn, and (2) to take the photograph from as far away as possible. As a general rule the longer the focal length of the lens, the less the parallax distortion at the edges of the photograph (this is a geometrical effect and has little to do with the quality of the lens).

## SHELTER WALLS AND CLIFF FACES

It is difficult to generalise about techniques for photographic coverage of near-vertical surfaces as one may or may not be able to photograph them from a reasonable distance. In general, however, only surfaces which are very nearly flat should be photographed with a wide-angle lens. Any surface which is curved or irregular should be photographed as a series of overlapping frames using a standard or moderate telephoto lens; each frame should be taken at right angles to the part of the surface being photographed and should include a graduated scale along the edge of the photograph so that successive frames can be printed to the same scale. In this way the series of frames can be assembled, using features of the surface as register marks, to provide a 'straightened-out' picture of a curved surface, which is then traced (and if possible annotated on a subsequent visit to the site).

If a wide-angle lens is used to photograph a complete surface which is not flat, whether in one or several frames, scale distortion will be caused (1) where the surface is not directly facing the camera, and (2) at the edges of each frame due to parallax effects.

## NEAR-HORIZONTAL SURFACES

A special problem is posed by near-horizontal surfaces, such as open air rock engravings, axe-groove sites and surface scatters of artefacts, because we cannot generally take photographs (other than oblique ones) from any distance. What is required is some sort of support to hold the camera two or three metres above the surface to be photographed.

I have seen a number of such devices, but all of them seem to suffer from one or more drawbacks, the most common being:

(1) The time necessary to set up some form of tripod over the surface to be photographed, adjust the angle of view (often vertical), frame and focus;

(2) the need for a step-ladder to carry out these operations;

(3) lack of portability.

The remainder of this paper sets out to describe in detail a simple device which allows one to take either vertical or inclined photographs. By using a single supporting column to which the camera is rigidly attached, individual framing and focussing of each photograph is eliminated. This means that the camera can be supported considerably further from the surface to be photographed (as there is no need for the photographer to be able to reach the camera for these operations), thus reducing parallax distortion at the edge of each overlapping photograph. As there are no tripod legs to be adjusted but simply a single column to be held in the right position at the moment of exposure, the time-consuming process of adjustment (and of finding somewhere to put the tripod feet without damaging anything) is eliminated. As a result, once reference points (e.g., the corners of 1-metre squares) have been marked out on the surface to be photographed, photographs of successive areas can be taken at the rate of one a minute, or faster; this compares more than favourably with the 10–20 minutes per photo rate, which is about the fastest I have observed for vertical photography with a three-legged support. Finally, the device described can be made for around $30 at the time of writing (excluding camera). Its total weight is less than 3 kg, which makes it ideal, for instance, for survey work involving the recording of rock engravings or surface scatters of artefacts in remote locations.

The basic camera support is an inclined column made of 2.5 cm (1 in.) square-section aluminium tubing. The camera is mounted on the end of this column in such a way that its field of view extends from the foot of the column outwards (Fig. 1). Framing is carried out simply by placing the foot of the column alongside the area to be photographed and lining up the alignment bar (Fig. 1 and Fig. 2d) with the edge of this area.

Focussing is carried out when the camera is first attached to the support and need not be subsequently modified as the camera remains at a fixed distance from the surface

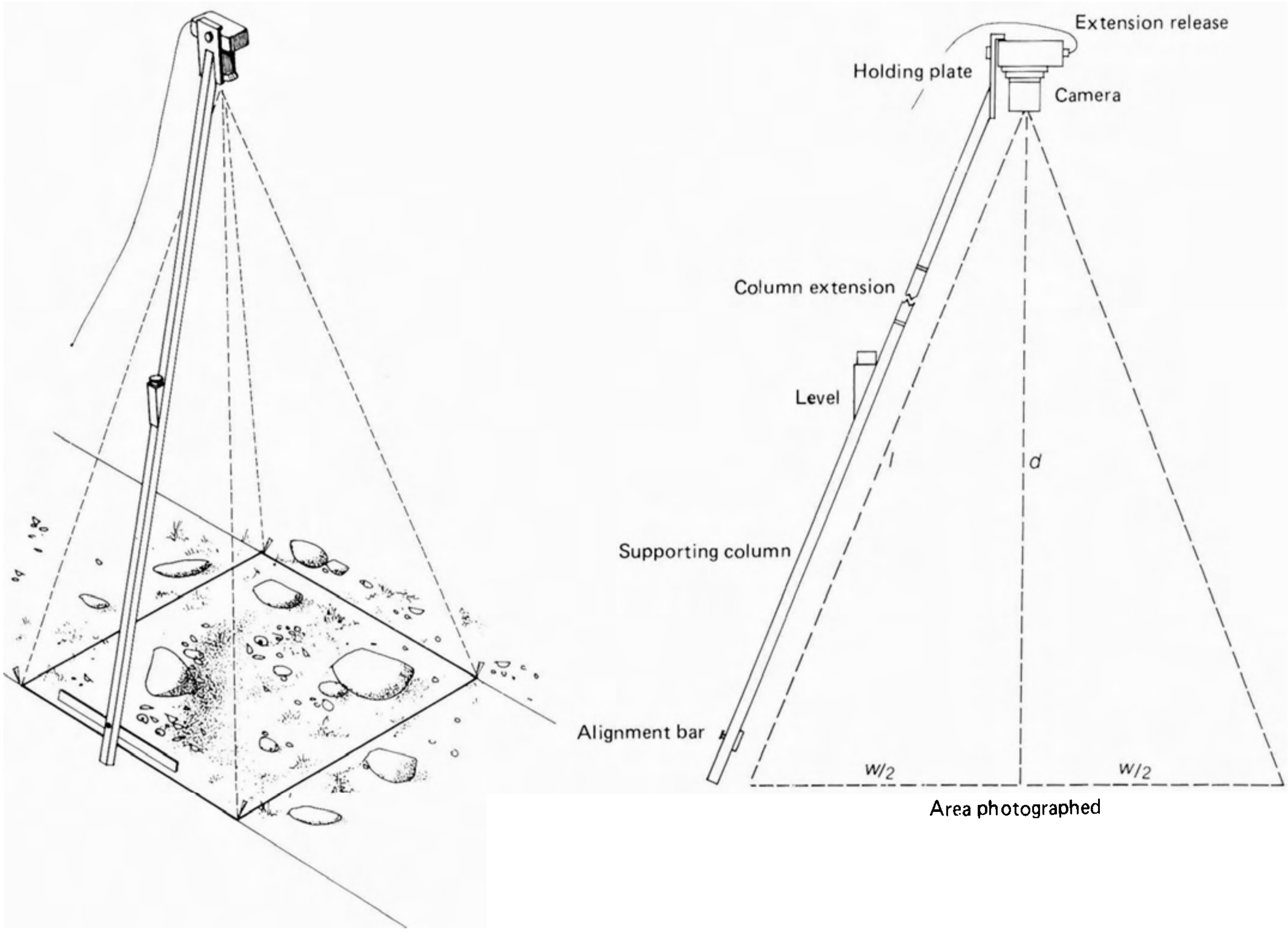



*Fig. 1*
*Device for photographing near-horizontal surfaces.*

being photographed (depth of field takes care of minor changes, see later). In order to maintain a constant orientation of the camera the column is fitted with a bull's-eye spirit level on a small Perspex block (Fig. 2b) cut in such a way that when the level is centred the camera points vertically downwards. For photographs of sloping surfaces the column is also fitted with a spirit level vial on an adjustable mount (Fig. 2b) which can be set to the desired angle.

Prior to photography it is best to mark out the surface to be photographed in squares or rectangles a little smaller (say three-quarters of the size) than the coverage of a single photograph, placing a small (1 cm) white-painted disc or flat-headed nail at each corner. This marking out ensures complete photographic coverage without gaps, and the markers serve as guide points in the assembly of the individual photographs. If the markers are considered to spoil the final assembly, they can easily be retouched out or removed just before each photograph is taken.

Successive photographs are taken by placing the foot of the column in the middle of, and just back from, the edge of each of the areas marked out, lining up the alignment bar with the edge and centering the level(s). The shutter is triggered with a long cable or pneumatic release. The device is shown in use in Fig. 4.

I was initially concerned about the possibility of camera shake with the arrangement described and I was not very happy about a camera waving around on the end of a 3-metre pole. In practice I found that one could get perfectly sharp results at 1/125 second exposure, or even lower speeds (even down to 1/8 second). For edge-to-edge sharpness and a good depth of field, an aperture of *f*4 or smaller is advisable, though acceptable results are produced at *f*2. As enlargements of this sort of photograph will not generally exceed about 12 magnifications there is no point in using slow/medium speed black and white film. A fast, 400 ASA film such as Tri X or HP5 (optionally developed in a speed-enhancing developer such as Acufine to give 1000 ASA or more) gives practically grain-free results at this magnification and allows the use of a fast shutter speed and small aperture and/or photography in poorer lighting conditions. Focussing is best performed by placing the foot of the column against a wall or tree, holding it so that the camera is aimed horizontally at the object in question, and focussing on it.

## CONSTRUCTION DETAILS

Two alternative methods of attaching the camera to the column are shown in Figs 2a and 3. The first method (Fig. 2a), whilst slightly more robust, requires accurate mitring and, by implication, access to proper workshop facilities. The second method (Fig. 3) requires only an electric drill, hacksaw, file and 5-minute epoxy

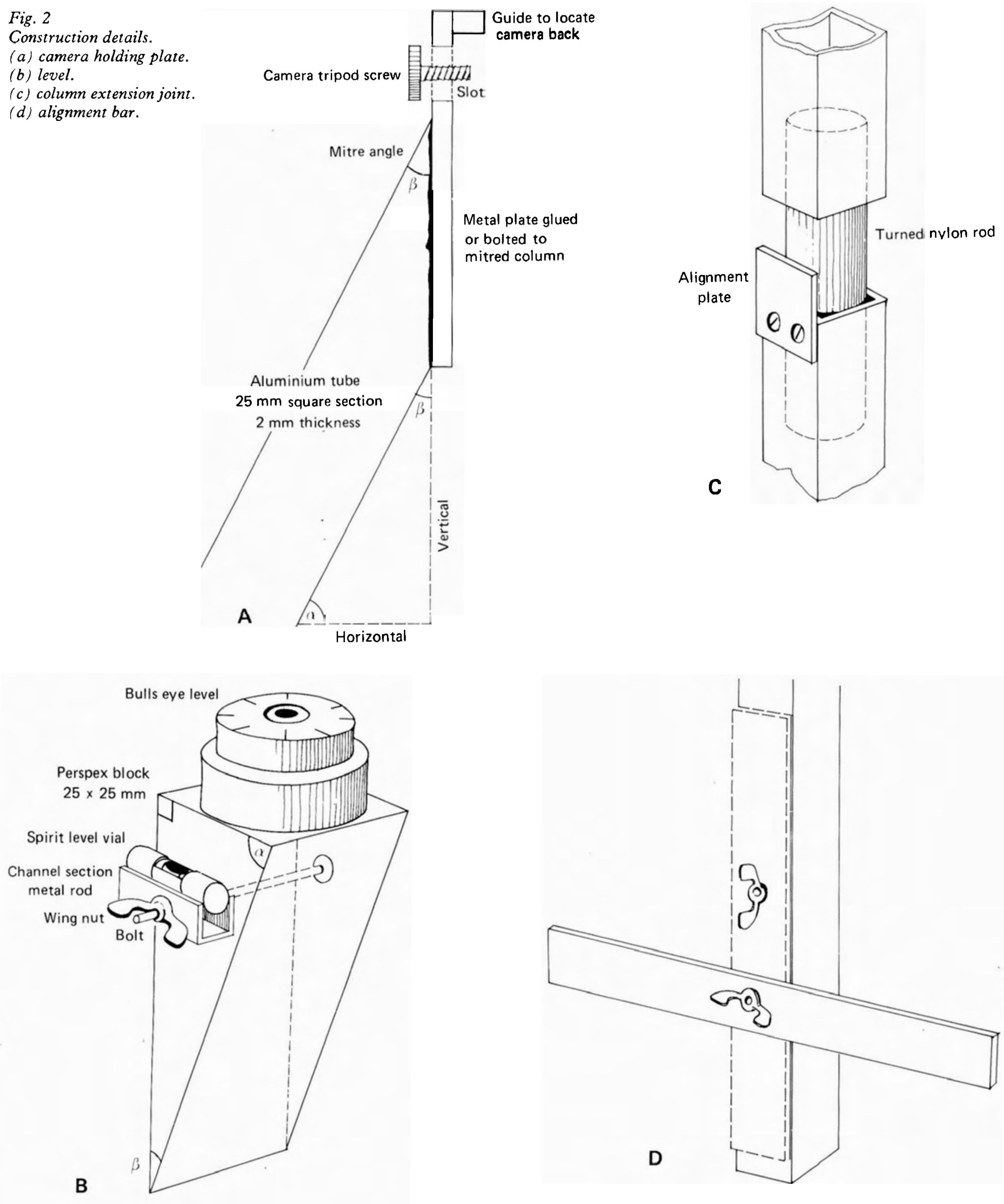
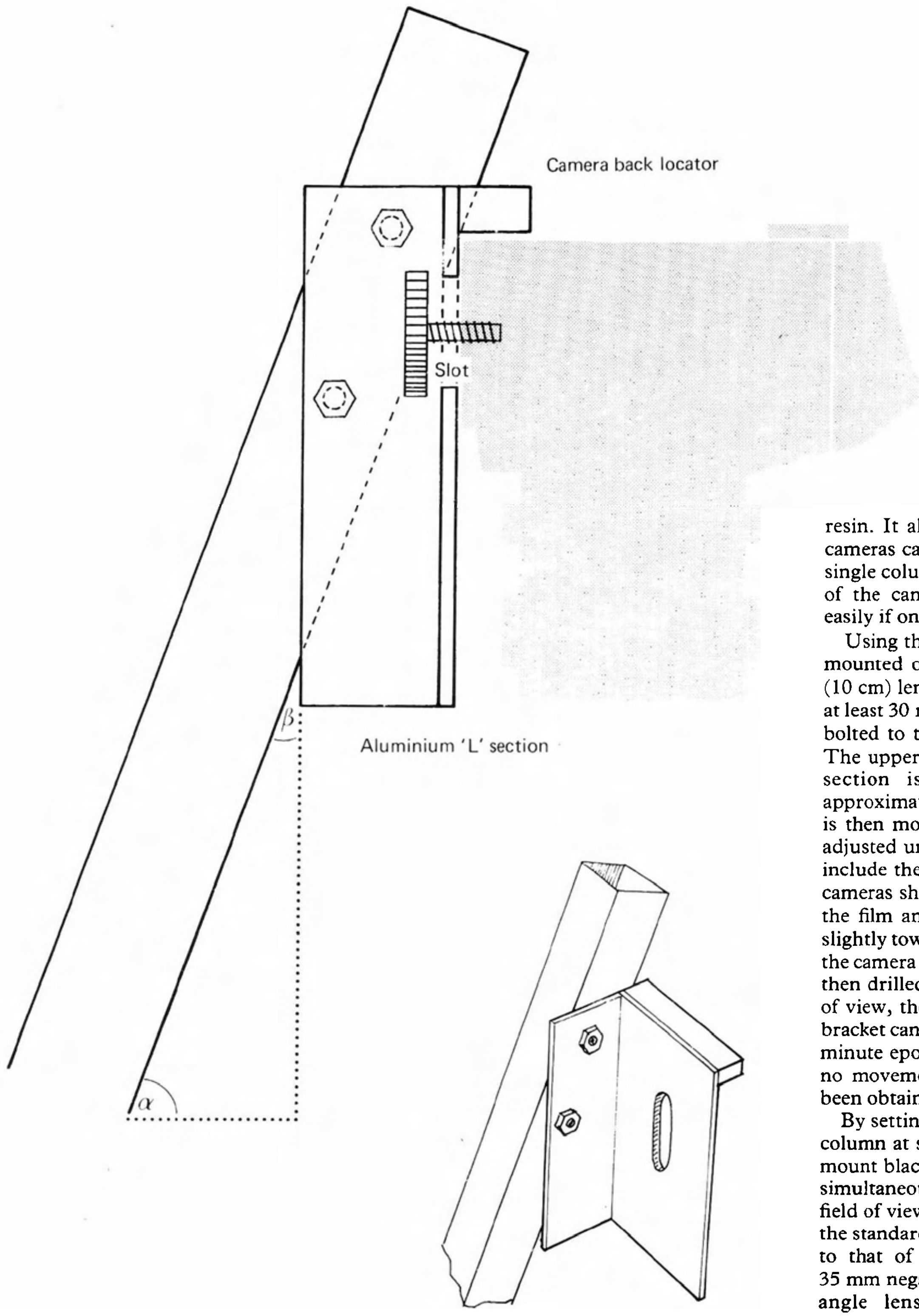



*Fig. 2*
*Construction details.*
*(a) camera holding plate.*
*(b) level.*
*(c) column extension joint.*
*(d) alignment bar.*

*Fig. 3*
*Alternative method of attaching the camera.*




resin. It also has the advantages that two cameras can be mounted side-by-side on a single column and that the mounting angle of the camera can be changed relatively easily if one changes camera.

Using the simpler method, the camera is mounted on a bracket made from a short (10 cm) length of 'L' section aluminium of at least 30 mm × 30 mm × 2 mm, which is bolted to the side of the column (Fig. 3). The upper hole is drilled first and the 'L' section is bolted to the column at approximately the right angle. The camera is then mounted on the bracket, which is adjusted until the field of view just fails to include the foot of the column (most SLR cameras show slightly less than appears on the film and the column will tend to flex slightly towards its base under the weight of the camera when in use). The second hole is then drilled and, after rechecking the field of view, the second bolt is tightened. The bracket can also be glued in position with 5-minute epoxy resin, to ensure that there is no movement once the correct angle has been obtained.

By setting a bracket on either side of the column at slightly different levels, one can mount black and white and colour cameras simultaneously. It is worth noting that the field of view of a 6 cm × 6 cm camera with the standard 80 mm lens is almost identical to that of the narrower dimension of a 35 mm negative taken with a 35 mm wide-angle lens. These two cameras can, therefore, be conveniently mounted side-by-side to cover, for example, a one-metre

square in black and white on 6 cm × 6 cm film for planimetry and on a 35 mm slide for a colour record. The two cameras can be triggered simultaneously with a double cable release.

The camera tripod screw passes through a hole in the mounting plate or bracket. This hole is best made as a slit by drilling two holes side-by-side and filing out the space between them so that the camera back can be slid up against the guide at the top. This guide serves to maintain the camera in line with the column. The surface of the mounting plate should be covered with a thin sheet of rubber or cork to provide greater friction. The triangular Perspex block (Fig. 2b) holding the bubble levels can be attached to the column with epoxy glue, and the levels can be glued to the block. Alternatively, the levels can be mounted on a bracket or brackets, similar to the one used for the camera, but horizontal instead of vertical. The (optional) joint(s) in the middle of the column are a more difficult problem, and are best entrusted to a workshop technician, as they must be rigid and maintain the two parts of the column in line. On my prototype a solid nylon rod was turned to fit tightly inside the two halves (Fig. 2c), and this has proved very rigid and easy to assemble. The base of the column can profitably be fitted with a rubber foot (e.g., a rubber bung pushed into the end of the tube) to increase friction and protect the surface on which the foot is placed.

I have found it best to start with a column which is longer than the calculated length and then saw lengths off it until I have the required areal coverage. This avoids the difficult problem of lengthening the column if one has inadvertently made it too short. If one wishes to reduce the rather generous margins that I have allowed (2.1 × 1.4 m to cover a 1 metre square) one can get away with as little as 10 cm all round by using a longer alignment bar; if the device is often used for photographing metre squares, the bar should ideally be 1 metre in length.

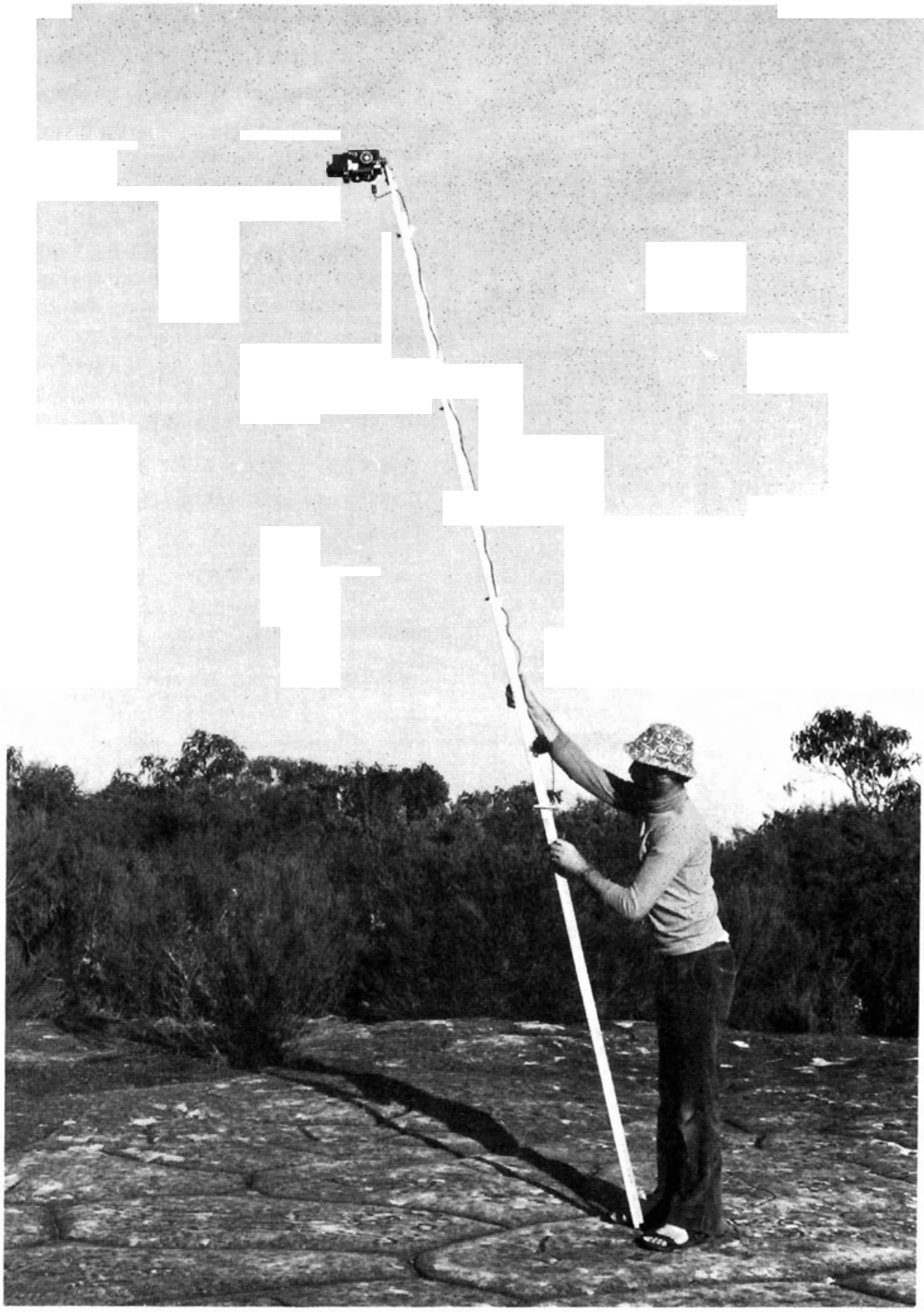


*Fig. 4*
*Device being used to photograph an engraved rock surface.*

## DIMENSIONS

To cover an area 1.4 m by 2.1 m on 35 mm film, or 1.4 m by 1.4 m on 6 cm × 6 cm film, before mitring the top end the column length should be as follows:

*35 mm camera:* 55 mm lens—335 cm; 50 mm lens—305 cm; 35 mm lens—220 cm.
*6 cm × 6 cm camera:* 80 mm lens—218 cm (film is actually 56 mm square).

The mitred end of the supporting column should be cut at the following angle to the column length ($\beta$ on the diagrams):

*35 mm camera:* 55 mm lens—12°; 50 mm lens—13.5°; 35 mm lens—19°.
*6 cm × 6 cm camera:* 80 mm lens—19.5°.

For other lenses, or different areal coverage, the column length and mitre angle can be calculated easily from the equations given at the end of this chapter.

*Note 1.* The shorter columns used with the 35 mm lens or a 6 cm × 6 cm camera are obtained at the expense of greater parallax error at the edges and corners of the photograph. This will render the joining up of photographs more difficult if the surface photographed is not entirely flat.

*Note 2.* One can use a shorter focal length lens than that for which the support was designed but the increased coverage will be lost along one edge by the inclusion of the base of the column.

## DESIGN CALCULATIONS

$l$ = length of column to centre of mitre (cm). The addition of approximately 6 cm gives the total length of column required before the mitre is cut.

$f$ = focal length of lens (cm).

$\alpha$ = angle between column and horizontal (degrees).

$\beta$ = angle between column and vertical = $90 - \alpha$ (degrees).

We assume that the optical centre of the camera lens is at the same level as the centre of the mitre, and offset 4 cm horizontally from it. This assumption is satisfactory for all 35 mm or 6 cm × 6 cm cameras.

For coverage of an area $w \times 1.5\,w$ on 35 mm film:

$$\frac{\text{image size}}{\text{object size}} = \frac{2.4}{w} \qquad \frac{f}{d-f}$$

*(from standard optical equations, d* = distance from lens to surface photographed)

$$d = \underline{(w/2.4)f} \qquad (1)$$

$$l = \sqrt{d^2 + (w/2)^2} \qquad (2) \text{ (by Pythagoras)}$$

$$\alpha = \text{Arctan}\,(d/\tfrac{1}{2}w) = \arctan\,(2d/w) \qquad (3)$$

For coverage of an area $w \times w$ on 6 cm × 6 cm film, only equation (1) need be changed to:

$$d = (w/5.6)f \qquad (1a)$$

For coverage of an area 1.4 m by 2.1 m on 35 mm film (a suitable size for photographing 1 m squares with *ample* safety margin):

$$d = \underline{(w/2.4)f}$$

$$l = \sqrt{d^2 + (w/2)^2}$$

$$\alpha = \arctan\,(2d/w)$$

| *55 mm lens* | *50 mm lens* | *35 mm lens* |
|---|---|---|
| $d$ = 325 cm | $d$ = 295 cm | $d$ = 207 cm |
| $l$ = 328 cm | $l$ = 300 cm | $l$ = 216 cm |
| $\alpha$ = 78° | $\alpha$ = 76.5° | $\alpha$ = 71° |

For coverage of an area 1.4 m by 1.4 m on 6 cm × 6 cm film with a standard 80 mm lens:

$d$ = 200 cm  $l$ = 212 cm  $\alpha$ = 70.5°.

## ACKNOWLEDGEMENTS

My thanks are due to Jim Neale, who constructed a prototype for me and made several suggestions on the material realisation of the device, to Win Mumford for turning my sketches into comprehensible diagrams and to John Clegg for the photograph in Fig. 4.

*Note:* Chapter submitted in 1979. Revised in April 1981.

# Chapter 7

# Photographing Australian prehistoric sites from the air

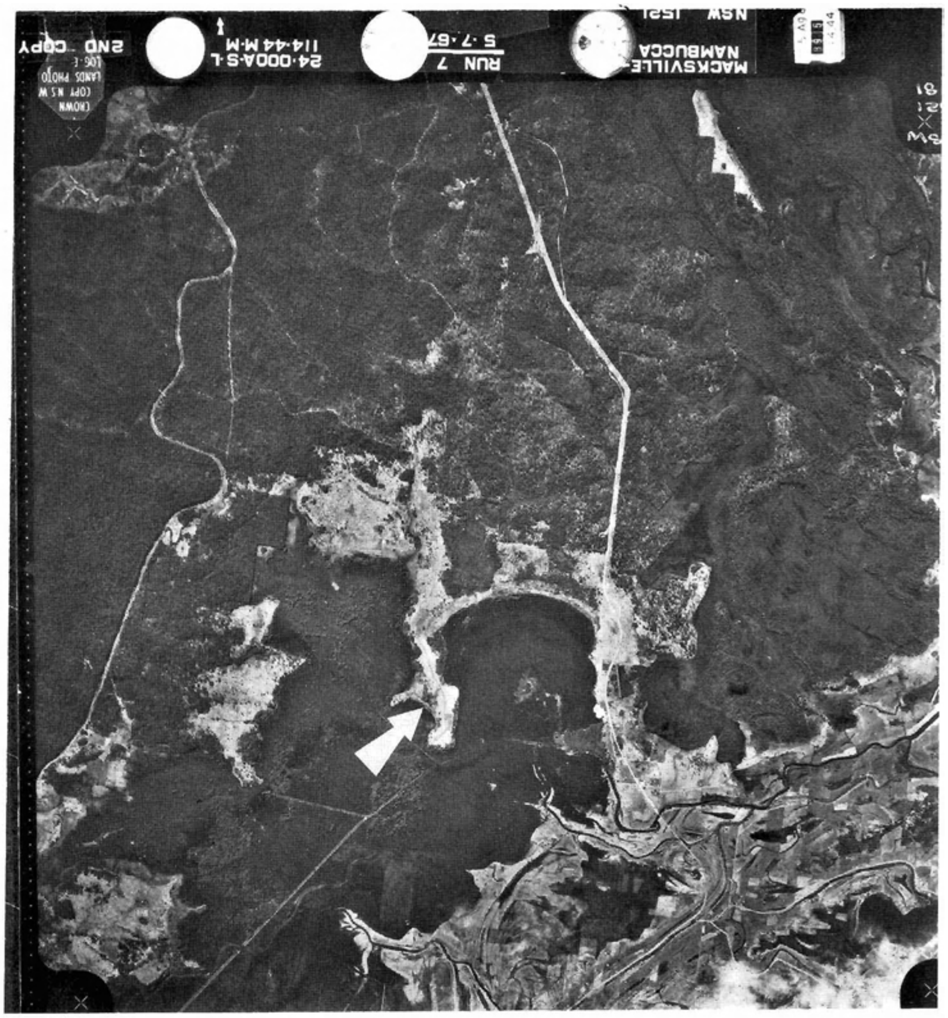
GRAHAM CONNAH
*Department of Prehistory and Archaeology, and*
ALAN JONES
*Department of Geography, University of New England, Armidale*

Australia possesses its own unique archaeological landscape upon which can be discerned traces of activity by both prehistoric hunter-gatherers and early colonial farmers. The material traces of prehistoric settlement were probably always rather slight and the impact of European settlement over the last two centuries has obscured or obliterated many of them. Nevertheless, one of the most efficient ways to study and record those traces is by means of archaeological aerial photography, a technique that is new in Australia although it has been used for some decades in other parts of the world. A marked advantage of this technique is that archaeologists can do a considerable amount of such photography for themselves. This chapter is written for those students of archaeology who would like to try their own hand with the flying camera but are not quite sure how to start.

## WHY BOTHER?

Before examining the technique itself it is relevant to ask what use it is in the context of Australian prehistoric archaeology. After all, there are already air photographs of one sort or another available for the whole of the Australian continent. No Australian archaeologist would dream of embarking on a piece of serious fieldwork without a supply of the appropriate air photographic prints for the area of study. The snag is, however, that this official photography, often done by governments for mapping purposes, is normally taken from a very great height. Examine Fig. 1, for example, which shows an official vertical photograph of part of the north coast of New South Wales just north of Kempsey. It is taken from a height of over 7300 metres and includes Clybucca 3 shell midden which can be seen on the archaeological oblique photograph shown in Fig. 2. The latter photograph was taken by one of us from a height of 175 metres. It is at once apparent that, although the official vertical photographic cover has great value for understanding environment and for predicting prehistoric resources, the human strategies adopted to exploit them and even the possible location of sites, it does not actually tell you anything about what the individual site looked like. However, not only is the official cover taken from far too great a height, it is also taken with absolutely no regard for archaeologically requisite conditions. Time of year, soil moisture content, vegetation growth, time of day, direction of light, angle of view: all these things which can be important in

*Fig. 1*
*Official vertical aerial photograph of the Clybucca region near Kempsey, NSW. Position of Clybucca 3 shell midden indicated by arrow (180 mm negative). Reproduction by permission of the Department of Lands, NSW.*



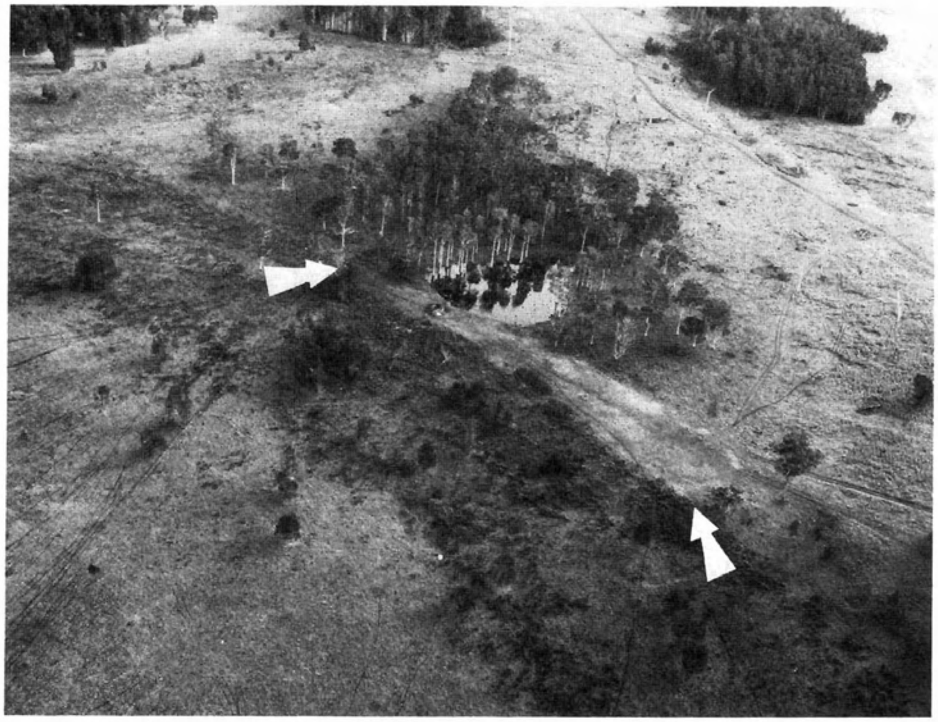


*Fig. 2*
*Low-level oblique aerial photograph of Clybucca 3 shell midden. Ends of midden indicated by arrows (35 mm negative).*

archaeological aerial photography have been chosen with topographic mapping in mind rather than archaeological needs. The lesson is clear, therefore: if you want aerial photographs that actually show the archaeological sites then they must be taken specially for that purpose. In practice, that means that we have got to get up there and take them ourselves.

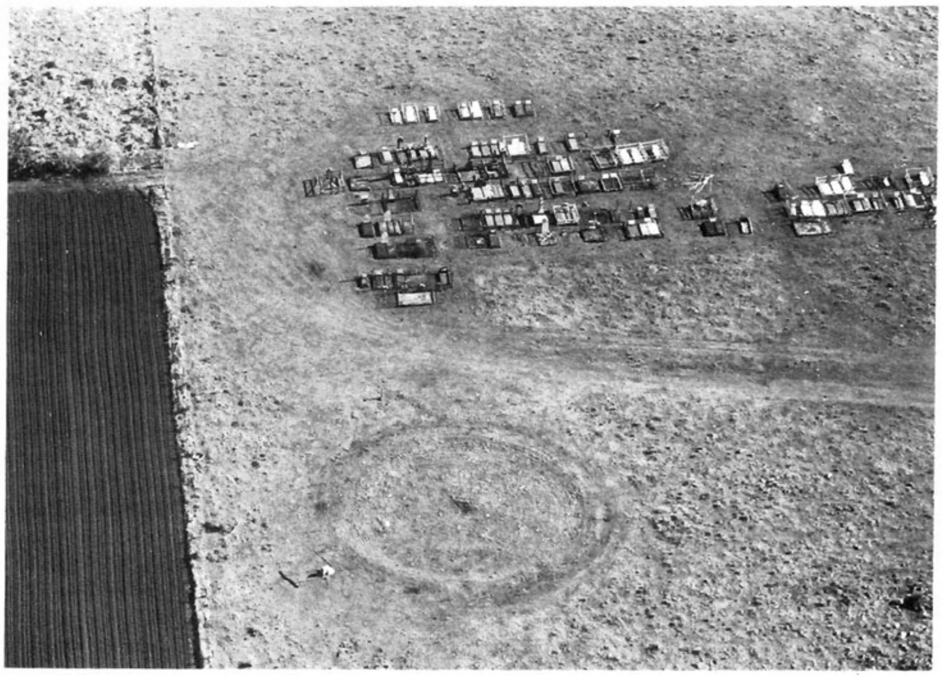
## IS THERE ANYTHING TO PHOTOGRAPH?

In other parts of the world archaeological aerial photography has been mainly devoted to the study of sites belonging to agricultural or urbanised societies. Hunter-gatherer societies tend to leave insufficient impact on the landscape to interest the aerial photographer. Nevertheless, distinct archaeological sites do survive, and in Australia there has been less time than in many other parts of the world for them to be erased by later agricultural activities. First of all there are actual earthworks and other structures, such as bora rings and stone arrangements. As Figs. 3 and 4 show, archaeological aerial photography of such sites is certainly worthwhile. Similarly, fish traps, either on the coast or on inland rivers (Fig. 5) lend themselves to aerial photographic study. Then there are the shell middens which are found on so many parts of the Australian coast and whose presence is sometimes apparent from the air due to differences in vegetation between the midden and the area surrounding it (Fig. 2). In addition there are quarry sites where stone has been obtained as raw material for stone artefacts. All these sites, and some others not mentioned, possess definite features that will show from the air and there are many other instances where archaeological air photography can be of value. Large open sites such as that at Lake Munga can be studied in the context of their present environment, and in some cases will also show evidence of their previous environment. Lengths of cliff face isolated in dense bush can be examined for the presence of rock shelters, as was done by P. J. Tresize in Cape York. Finally, low-level aerial photography can provide more detailed information about the environment of an area and its likely prehistoric resources than can the small-scale, high-level photographic cover that archaeologists usually have to work with.

## WHAT CAN ARCHAEOLOGICAL AIR PHOTOGRAPHY TELL US?

Over the past few decades there has been frequent discussion in archaeological textbooks as to why and how archaeological sites show from the air. Therefore, we do not think that it is necessary to examine this matter here. There has, on the other hand, been less discussion of the particular *uses* of archaeological aerial photography to the archaeologist. Irrespective of geographic

*Fig. 3*
*Low-level oblique aerial photograph of **Tucki Tucki bora ring near Lismore**, NSW (35 mm negative).*



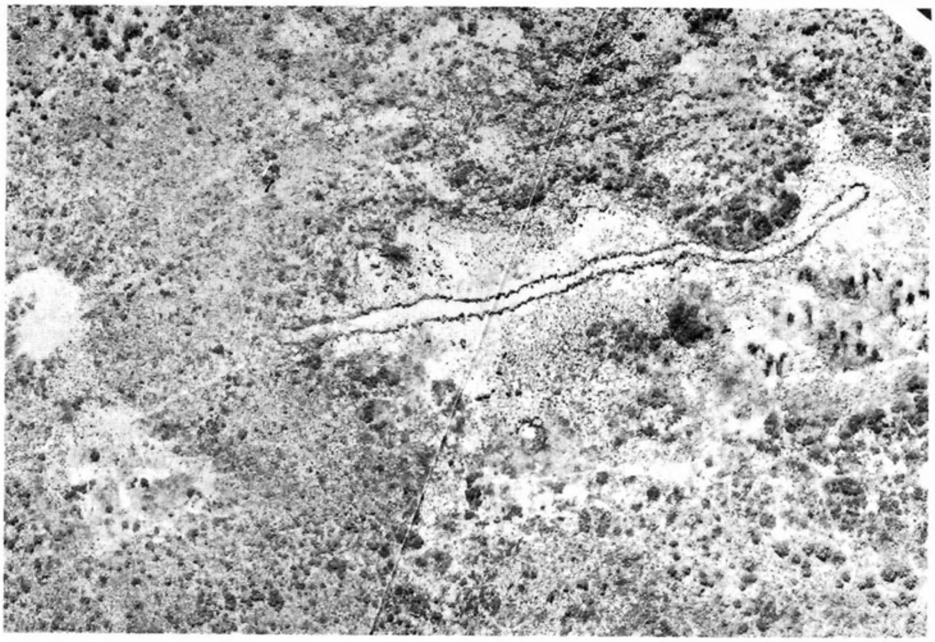


*Fig. 4*
*Vertical aerial photograph of one of the small ceremonial pathways at Pindera Downs near Tibooburra, NSW (70 mm negative).*

details which would be expensive of time and money to survey on the ground. The low-level vertical air photograph gives at once an accurate record that can be readily translated into a usable map by enlarging the negative to fit surveyed ground control points. (Where the tilt of the photograph is large, photogrammetric rectification techniques must be used.) Not only that but the photography can be reflown at intervals of 5 to 10 years to *monitor* changes over time: a consideration that is clearly important for those government bodies that have the thankless task of looking after the conservation of Australian prehistoric sites.

location or the date of the sites to be investigated, it seems to us that there are four main ways in which such photography is useful.

(1) The first and the most obvious use is as a highly efficient means of *recording* sites. Sites such as that seen in Fig. 6, for instance, are made up of very complex

*Fig. 5*
*Vertical aerial photograph of part of the fish traps in the River Barwon at Brewarrina, NSW (70 mm negative).*





*Fig. 6*
*Vertical aerial photograph of the largest of the ceremonial pathways at Pindera Downs near Tibooburra, NSW (70 mm negative).*

(2) Another important use is to *elucidate* the sites which are photographed. Western scholarship persists in endowing verbal description with respectability but associating visual description with the kindergarten. Most academics, for instance, still talk about 'visual aids' not 'visual explanation'. It is this latter phrase that best defines the elucidatory role of archaeological air photography. For example, even a brief glance at Fig. 4 will give a clearer understanding of such a site than one would obtain from ground-level photographs, or even from a brief visit to the site itself. Cast your mind back to the first time that you flew in an aircraft: did you not discover a sudden new understanding as you looked down on the landscape? It is such a 'new understanding' that low-level aerial photography can provide of archaeological sites.

(3) For years general archaeological textbooks have told the reader how aerial photography can *discover* previously unknown sites. Such books, we would stress, are usually written by people who have never done any aerial photography themselves. Certainly this is an important use of aerial photography but our impression is that in the Australian prehistoric context this is an application that will prove somewhat limited. It is possible to discover sites, and it is possible to use specially flown photographs as a means of systematic search for previously unknown sites, but to the best of our knowledge neither has yet been achieved on any scale in the Australian situation.

(4) Related to site discovery is the possibility of site *prediction*, which has been mentioned already. Given good, large-scale, low-level aerial photographic cover of an area, one should be able to predict where sites might be situated and then search for them on the ground. In this prediction the reasoning would be from environment (or likely prehistoric environment) to available resources in such an environment, to human strategies for exploiting those resources, to possible location of sites associated with such exploitive strategies. The obvious example of such a predictive use of air photographs would be in the search of an estuary for shell middens, where surface investigation was made difficult by the complex intermixture of water, mud and mangrove. Such an application of aerial photographs is already familiar to many fieldworkers, of course, but in the main they are restricted to the high-level aerial cover which is officially available. Although this can be enlarged fairly satisfactorily to impressive proportions, it does not have the potential quality of specially flown, low-level work.

## TAKING ARCHAEOLOGICAL AIR PHOTOGRAPHS

### Types of aerial photograph

There are two main types of aerial photograph (Fig. 7). The most useful for mapping purposes is the *vertical* air photograph. Unfortunately, few aircraft available for hire are provided with facilities for vertical photography. Such facilities usually consist of a hole through the floor of the aircraft but a mounting on the outside of the aircraft is sometimes used. It is for this reason, amongst others, that Cambridge University in England owns its own aircraft for archaeological air photography. In Australia only certain government bodies and certain commercial companies have aircraft that are fitted up in this way, and the only vertical air photography that we have been able to do has been done with the kind cooperation of the National Parks and Wildlife Service of New South Wales, which owns such a plane and has its own vertical air cameras. Vertical photography, indeed, usually requires the use of specially built air cameras, although it is possible to use any larger format camera for this purpose. In addition, for vertical photography, the camera must be set up in a rigid mount which is usually fastened to the aircraft floor. Also, vertical photography will need to be taken with a 60% overlap of the negatives if it is to be used stereoscopically and this entails the possession of an instrument called an intervalometer to adjust the speed at which exposures are taken to the speed of the aircraft. The camera and intervalometer are run electrically from the aircraft power supply.

Because of all these requirements it is

only the second type of air photograph, the *oblique* air photograph, that most archaeologists will be able to produce for themselves. Indeed, most of our work has been of that type: it has the great advantage of being simple, and can be done with a hand-held camera. Most of what we have to say in this chapter is concerned, therefore, with the low-level oblique air photograph although many of the points discussed are equally applicable to vertical photography also. From the archaeological point of view, however, the oblique photograph does have one advantage: there is a greater realism in the perspective view thus produced. Also, if one really needs to draw plans or maps from oblique photographs there are well-tried methods for doing so (Burnside, 1979: 52–67).

Oblique photographs in which the horizon appears are known as high obliques. Low obliques do not include the horizon. The choice of low or high obliques depends on whether the aim is a close-up of a particular location or a more general view showing a site in relation to its surroundings.

Flying regulations vary from place to place and it is necessary to check these with the pilot before deciding on flying heights.

The scale of the photographs depends on the flying height of the aircraft above the ground, the angle of tilt of the camera and the focal length of the camera lens. The scale of a vertical photograph is given by the equation:

$$\text{scale} = \frac{\text{lens focal length}}{\text{flying height above ground}}.$$

This is commonly shortened to $f/H\text{-}h$ where $f$ is the focal length, $H$ the flying height above sea-level, and $h$ the ground elevation. The formula for the scale of an oblique photograph is more complex since the scale changes across the photograph, nearer objects being at a larger scale than those further away. The scale of a tilted photograph is given by the formula:

$$\text{scale} = \frac{f - y \sin\theta}{H - h},$$

where $y$ is the distance from the isocentre and $\theta$ is the angle of tilt.

For a photograph with a tilt of 10° and a focal length of 100 mm, taken from a height above ground of 500 m, scale will vary as follows:

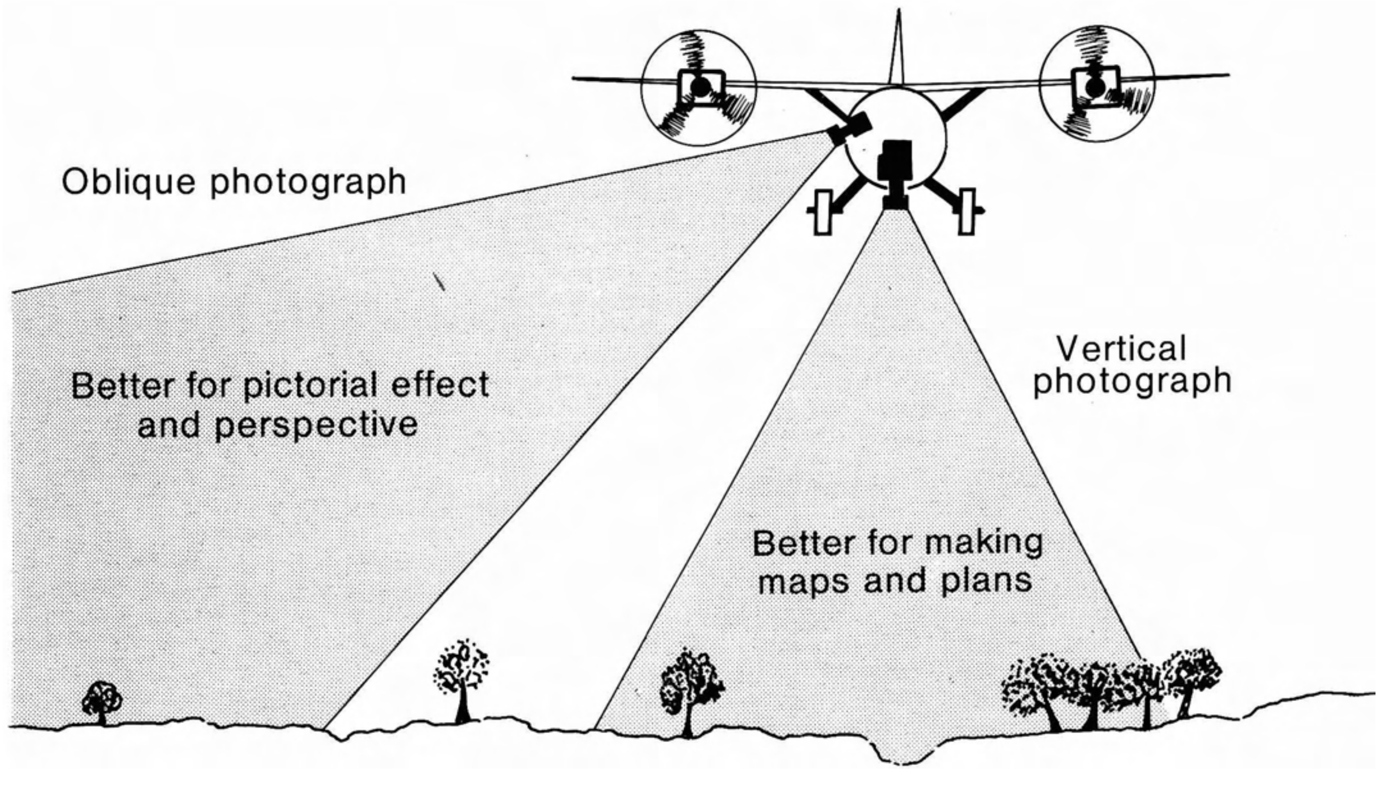
| $y$(mm) | Scale |
|---|---|
| +100 | 1:4260 |
| 0 | 1:5000 |
| −100 | 1:7260 |

In practice, our oblique photography is usually done at heights from 100 to 450 metres. For detailed work the lower the better, but at very low heights some sites will become too large to be seen in their totality. Also, although one pilot has flown for us at a height of as little as 15–20 metres we found that the apparent ground speed was then so fast that it was very difficult to avoid blurring of the negative image. Nevertheless, low-level oblique photography does involve getting down to heights that are usually low compared with the normal charter work done by most pilots. The type of landscape over which one is flying will clearly affect the safety factor. Here, the budding archaeological air photographer should remember one important rule: his or her business is the photography; the pilot's business is safety. If the pilot says 'no' to any required manoeuvre or height then it is most unwise to argue.

## Organising the aerial photographic sortie

Successful aerial photography requires planning and teamwork. Many factors must be considered before take-off since flying costs are increasing annually and it is important not to waste time in the air and equally important to finish up with really useful photographs. It is essential to decide

*Fig. 7*
*Types of aerial photograph.*



which sites or what area one wishes to photograph, as in many instances the pilot will need to file a flight-plan before departure. Also it is useful to have visited the area on the ground previously and to have looked at the position of any surrounding hills or the direction in which the shadows of rocks or trees will fall at different times of the day. Such things will affect flying height, direction of approach and best time of day for photography. A visit to the area beforehand can also give up-to-date information on surface vegetation, which can vary in Australia not only with the season but also because of drought or unusually heavy rain. When booking the plane, which is usually best done a few days before the flight, it is important to tell the pilot what your intentions are and, if you have not flown with that particular pilot before, to explain the purpose of the flight. It may be that the place to which you wish to fly is subject to flying restrictions because of the near presence of an airport or of a military establishment. The pilot will be able to tell you if this is the case and in such circumstances special permission may need to be sought before the flight.

In planning a photographic sortie it is better to set out with fairly limited objectives and accomplish them than to try to photograph a large number of subjects and end up with only mediocre, muddled photographs as a result. We have found from experience that 1½ hours of flying time is quite enough for the average sortie, 2 hours is about the maximum. Also, weigh up the cost of a long approach and return flight to and from the area of interest as against driving to a local airfield by road and hiring a plane close to the area to be photographed. It is better to do two or three brief flights, we have found, than to attempt the same volume of work in one long flight.

You need to fly in optimum weather conditions. You need sunlight, clear skies, little or no wind and no haze. In practice, for both this reason and for reasons of relief photography, early morning is often the best time. Get to the airfield by 6.30 a.m., take-off at 7.00 a.m. and be back by 9.00 a.m., varying this, of course, to suit the time of year.

Make sure that your cameras are loaded and set to the most likely settings before you take off. Make sure that you have a neck strap on the camera, and use it. Do not attempt anything too complicated with the camera once you are flying. One of our pilots recently told us of a commercial photographer he took up on one occasion who succeeded in dropping a telephoto lens out of the window of the aircraft. Clearly, neither the authorities nor the local people would like this very much!

Once airborne, remember that successful archaeological air photography does involve teamwork as stated already. In small aircraft with four to six seats it is best for the photographer to sit beside the pilot in the front of the aircraft. Then he can talk the pilot into the position relative to the site that is best for photography. In the seat behind should sit a third person who looks after the maps, the detailed navigation, spare photographic equipment, any necessary adjustments to the camera, and the exposure record. The latter is essential since air photographs are very easily confused one with another and it is vital to write down the details of the exposures as they are taken. Thus the photographer, with his or her eye held on the camera viewfinder, will be shouting instructions to the pilot and the person behind. In most small aircraft this will mean *shouting*, because the engine noise can be fairly loud. When actually taking the photographs, the photographer should get the pilot to approach the site in every way possible, varying the height, the direction of approach, the angle down to the subject and the tilt of the plane. It is worthwhile for the photographer to have some informal knowledge of flying so that he or she is aware of the limitations of such movements. The good air photographer composes the picture just as any good photographer does. There is art as well as science in this business. Lastly, if you are going to fly round and round a spot where there is a property telephone the people the night before and warn them. A small plane flying round and round at a low level can be more than just annoying. It may be mistaken for a plane in trouble, with a pilot looking for somewhere to land.

It will be apparent from the foregoing that there is much advantage to be had from the same group of people working together time after time. In particular, a great deal depends on the pilot knowing what is wanted. We would specifically acknowledge the services of Howard Creamer of the National Parks and Wildlife Service, who has flown with us with great skill and patience on a number of occasions.

## Aircraft

For oblique photography to be of the highest quality the aircraft used must have a window which can be opened and closed during flight, so that the photographs do not have to be taken through a sheet of Perspex. With some aircraft the door can be removed to give a better view. Such a solution might not meet with universal approval, however. When photography is done through an open window, as is most usual with oblique work, the window should only be open at low speeds and it is best to let the pilot decide when it should be opened and when closed. High-wing aircraft are preferable to low-wing aircraft; from the latter many photographs will include large expanses of wing. In particular, the single-engined Cessna 172 and Cessna 182 have been found to be particularly suitable and we have also used a twin-engined Partenavia 68B although this only has a small circular window. Even with these aircraft it is difficult to get a steep depression angle, however, and it is often necessary to roll the plane partly onto its side to get a good close-up low oblique shot. Photographs should not be taken through the exhaust from the aircraft engine. For aerial photography the aircraft should be able to fly at less than 100 knots (185 km/h) during photography. Where the sites to be photographed are some distance from the airfield, an aircraft with a low cruising speed might be a disadvantage, however.

Some photographers might have access to a helicopter which has obvious advantages over a fixed-wing aircraft. Hovering over a site for an extended period, however, is not recommended as it tends to increase vibration, apart from being hard on both pilot and aircraft. The major disadvantages of helicopters are their higher running costs and comparative rarity. A major advantage for smaller prehistoric sites, however, is the helicopter's ability to fly safely at lower altitudes than fixed-wing aircraft.

## Cameras

A wide variety of cameras are available for aerial photographic work. These range from cameras widely used for conventional ground photography through to specialised photogrammetric cameras. A convenient way of grouping cameras is according to the size of the film that they use and the negative produced. The negative size is normally referred to as the camera *format*.

For aerial photography it is inadvisable to use anything smaller than 35 mm film, which has a rectangular format of 24 mm by 36 mm. While presentable photographs may be produced with smaller formats there are limits to the size of enlargements from very small negatives. Approximately twice as large as the 35 mm film is the 70 mm film which produces a 55 mm

square format. An alternative to 70 mm film is the more widely available 120 roll film giving a similar format. These cameras are suitable for both oblique and vertical aerial photographs. Larger formats than this are available though they are generally used for vertical aerial photography since the weight and size of such cameras makes it difficult for them to be hand-held. However, if vertical photographs with a larger format are needed, it is frequently possible to purchase older cameras fairly cheaply.

In selecting a camera several considerations need to be borne in mind. The cost of the camera, and also of the film, need to be carefully considered. The processing of 70 mm colour film or any larger format film is both more expensive and less widely accessible than 35 mm or 120 film which can be processed through any pharmacist or photographic shop. The size and weight of the camera is another important consideration, as is ease of operation in the air. Flying round and round an archaeological site leaves one little time to do more than press the shutter.

Since the photography is being taken on the move and since there is airframe vibration, a fast shutter speed is needed. A minimum speed of 1/250 second is essential and 1/1000 second highly desirable, especially for low-level operations. A hand-held mount for the camera, preferably with two hand-grips, is a useful accessory which may be purchased for some of the larger cameras, or made with little effort. Many cameras today have automatic exposure control and this too is useful though it is necessary to test its operation in the air as well as on the ground to get good exposures. Some of the more expensive cameras have a motor drive which automatically advances the film between exposures. Where photographs may be taken in rapid succession this is an essential accessory. The focus of the camera used will need to be kept at infinity. Because the focussing ring on some cameras can be inadvertently knocked round in the cramped conditions of an aircraft or in the heat of the moment of air photography it is a good idea to fix the ring in the infinity position with masking tape.

## Camera lenses

Most cheaper cameras are sold with a single lens which may not be changed. This may be a major limitation since the focal lengths provided are often fairly short and to get a good negative requires low flying. For general pictorial work, where an overview of an area is wanted, a focal length of around 50 mm is adequate, but for detailed recording of Australian prehistoric sites, the majority of which are fairly small, longer focal lengths of 100 mm to 150 mm are needed, although it should be noted that focal lengths of over 100 mm should only be employed with larger format cameras. For very small sites even longer focal lengths would be useful, although as the focal length increases so does the length of the lens and the difficulty of holding the camera still to avoid a blurred image. Also there is a point beyond which one cannot magnify a moving image without blurring the photograph. Longer focal lengths are available for vertical aerial photography where problems of stability are minimised by the camera mounting.

The lens purchased should be of as high a quality as funds allow as this is a major factor in the quality of the final product. For archaeological air photography the ideal times are often early or late in the day when lighting conditions are less than ideal from the exposure point of view. To improve the prospects of obtaining good photographs a 'fast' lens should be used, that is, one with as large an aperture as possible. The aperture is normally recorded as a number following the letter *f* and is known as the *f* stop. This is derived by dividing the lens focal length by the width of the lens opening. Thus the larger the opening, the smaller the *f* stop. The speed of the lens is the *f* stop for the maximum lens opening. For 35 mm and 70 mm cameras *f*2.8 or faster is desirable.

## Films

A wide selection of films is available for most types of camera. It is possible to consider two main types of film, those which produce black and white prints and those which produce colour. Most black and white films belong to the group of films termed panchromatic. This means that they are capable of recording the same parts of the spectrum as the average human eye and recording them as shades of grey according to the intensity and wavelength of the reflectance from an object.

In selecting a suitable film a choice has to be made on the basis of film speed and resolution (the ability of the film to record small objects). The speed of the film is a measure of the speed with which it responds to light. The faster the film speed, the shorter will be the shutter speed. Unfortunately, as the speed of the film increases, so its resolution decreases. For most conditions a film with an ASA speed rating of 125 will give good results for a shutter speed of 1/500 second. Under poor lighting conditions a faster film may be required.

A further variable is the contrast of the film. The further away the camera is from the subject to be photographed, the lower is the difference in reflectance from the bright and dark areas. With aerial photography, therefore, the contrast of the area to be photographed is often reduced. This decrease in contrast is made worse by increasing the flying height. Special aerial films are available in some formats and these enhance the contrast in the scene photographed. It is possible to talk of the contrast of the subject and of the film. Thus decreased subject contrast can be alleviated by increased film contrast. Experience indicates that for low-level work (less than 1000 metres above ground level) it is not worth using such films, particularly if a yellow filter is used (filters are discussed later). Since there may also be a minimum order attached to such films (which could provide enough film for two to three years) most users will find films available from conventional sources adequate for their purposes.

Black and white infra-red films extend the sensitivity of panchromatic films into the near-infra-red part of the spectrum. It should be made clear that such films are not heat-sensitive. They are useful for measuring variations in plant health, which may indicate an archaeological site. Greater care needs to be taken in handling such films than is the case with panchromatic films. Black and white infra-red films generally produce high-contrast photographs, particularly when visible light is excluded by the use of an appropriate filter. For 35 mm work it is just as easy to use colour infra-red film which can produce better results. With larger formats colour infra-red increases in cost and it may be necessary to use black and white infra-red film for economic reasons.

Colour films are increasingly being used and may be either reversal or negative films. The reversal film produces colour transparencies while the negative colour, as its name implies, produces negatives from which colour prints may be made. The purposes for which the photographs are to be taken are important in deciding which to use. For slides to use as illustrations in lectures 35 mm colour reversal film is ideal. Where colour prints and enlargements are needed then colour negative film is more useful as it is possible to vary the colour balance of a print and make it greener, bluer, or whatever is needed. Processing

and particularly printing colour film can become very expensive in comparison to black and white photography and reproduction in books and other publications is frequently restricted to black and white. The cost differential between black and white photography and colour also increases as the format increases.

Another type of film is the colour infra-red film which has one of its three layers sensitive to near-infra-red radiation. The colouring of the result is that healthy vegetation is generally red to reddish brown in colour with a sharp contrast between vegetation and bare earth or rock. As with all infra-red-sensitive films, variations in the status of vegetation and soil moisture may be visible in the photographs. Again, 35 mm photography with such a film is relatively cheap and easy. Larger formats become increasingly costly.

With smaller format cameras it is often possible to construct a bar to hold several cameras which can be fired simultaneously and to use different films in each camera. Useful photographs may be taken in this way and new features discovered. For obtaining photographs for record purposes, however, the 70 mm format is preferable, and this frequently means using panchromatic film.

### Filters

An ultra-violet (UV) or haze filter can be useful in air photography, and in colour infra-red work a Kodak Wratten 8 filter or similar is essential. In black and white infra-red photography a Kodak Wratten 25(A) or 89B filter must be used to exclude visible light. The most commonly used filter in aerial photography, however, is the yellow filter, which improves contrast considerably when using black and white film. As most aerial photography is done with black and white film, the yellow filter is in practice nearly always in use.

## USING THE PHOTOGRAPHS

Apart from the purely pictorial aspects of aerial photography the aerial photographs may be used to make maps. The ability of the photograph to be used successfully for mapping depends initially on the quality of the camera. Ideally the camera should have a between-lens shutter rather than a focal plane shutter. The latter creates problems with the geometry of the photograph. In addition, the quality of the lens also influences the geometric quality of the photographs. The cheaper the lens, the greater the displacement of points towards or away from the photograph centre (known as radial lens distortion).

To convert the photograph to a map one needs control points. These are features on the photograph which can be recognised in the field and which have been surveyed to obtain their true planimetric position. Provided the tilt of the photograph is small it is possible to enlarge the photograph so that the distances between control points on the enlargement coincide with the distances measured in the field, taking into account the scale of the enlargement. When the photograph tilt increases this can be corrected by tilting the board on which the photographic paper is to be placed. This simulates the photogrammetric technique of rectification. The board is tilted to get the best fit of the photograph points on those plotted on the control sheet based on the field survey. Provided the ground around the archaeological site is flat, the 'rectified' enlargement may be used as a map.

An alternative graphical method of transferring detail from the photograph to a map is based on a perspective grid. This method is described in the Appendix. Where significant relief is present stereoscopic pairs of photographs must be used and methods of correcting for relief errors will be found in most photogrammetric textbooks. However, since they require photographs to have tilts of less than 3°, it is unlikely that the amateur aerial photographer will be able to use these methods.

## CONCLUSION

In this chapter we have discussed how you may take your own archaeological air photographs and we have emphasised low-level oblique photography. Our discussion has been merely an outline of the techniques, however. For those who wish to try it, the best way is to get up there and see how you get on. Start with a good 35 mm camera, preferably motor-driven, and work up from that to a larger format. If you do not wish to do your own aerial photography, but would like some done, then contact us and we may be able to help you.

## ACKNOWLEDGEMENTS

We would like to acknowledge the financial support of our own archaeological air photography project by the Australian Research Grants Committee and by the University of New England. We also wish to express gratitude to the National Parks and Wildlife Service of New South Wales for their generous practical support.

## APPENDIX

### Mapping from photographs: graphic methods

Where only a few points need to be transferred from the photograph to the map the four point anharmonic (or paper strip) method is very useful. For this, four points surrounding the area to be covered should be found which can be identified on both the photograph and the map. The latter is necessary to give scale but need only have minimal detail on it. The method is as follows (Fig. 8):

(1) From *a* on the photograph and *A* on the map draw rays to *b*, *c* and *d* and *B*, *C* and *D* respectively.

(2) On the photograph draw rays from *a* to *x* and any other points to be plotted.

(3) Place a strip of paper across the pencil of rays from *a* and mark where each line meets the edge of the paper strip.

(4) Place the paper strip on the map across the rays from *A* and align it so that the marks made to *b*, *c* and *d* coincide with the rays to *B*, *C* and *D*.

(5) From *a* draw rays through *x* and any other marked points as shown.

(6) Repeat steps 3–5 using the rays from *b* and *B*. The position of *x* will then be fixed by the intersection of the rays from *A* and *B*.

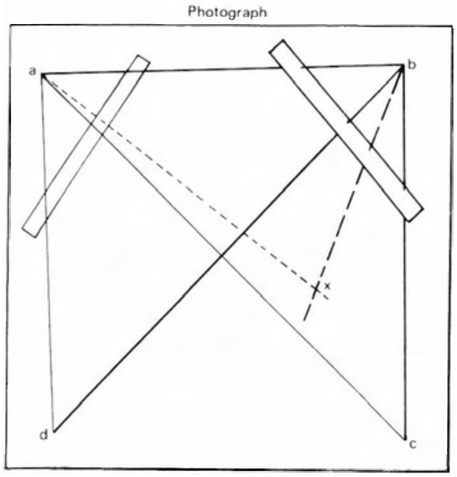
Where more than a few points are to be transferred the paper strip method becomes tedious and a grid method is more appropriate. Unfortunately, grids cannot be constructed as would be done if one were simply enlarging or reducing a map, because the midpoint of a line on a photograph need not be the midpoint of the corresponding line on the ground.

Construction of the grid (often referred to as the Union Jack Grid) is as follows:

(1) Select four points to surround the area to be mapped, which can be identified on both the photograph and available map. If a point is not available in a given area it may be possible to locate one using the paper strip method with four other points.

(2) On both map and air photograph draw the sides of the quadrilaterals and the two diagonals.

(3) Select two points, *x* on *ab* and *y* on *bc*, so that when lines are drawn from these points through the intersection of the diagonals the resulting figure is reasonably symmetrical.



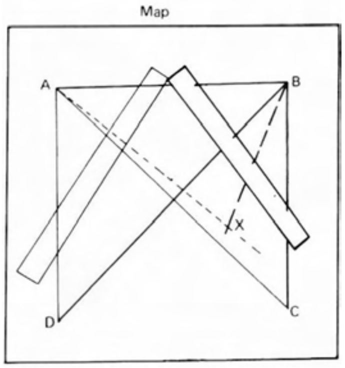



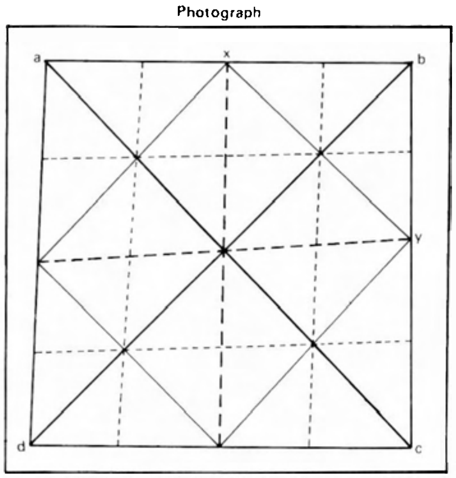

*Fig. 8*
*The four-point anharmonic (paper strip) method.*

(4) Transfer $x$ and $y$ from the photograph to the map using the paper strip method. If you use $d$ as the pole you need only draw one set of construction lines as $X$ and $Y$ should lie on $AB$ and $BC$ respectively.

(5) Draw lines from $x$ and $y$ and $X$ and $Y$ through the intersection of the diagonals.

(6) In the smaller quadrilaterals draw in the other diagonals.

(7) Join up the intersections of the diagonals and continue steps 6 and 7 until the triangles are small enough to allow detail to be safely transferred from the photograph to the map.



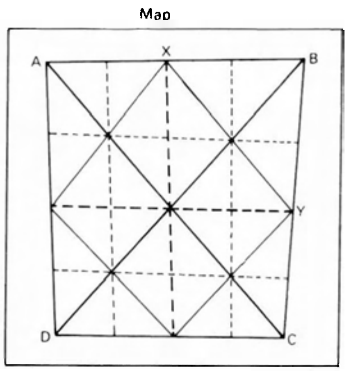




*Fig. 9*
*The Union Jack method.*

Other types of grid may also be constructed but this is the simplest. As with the paper strip method only tilt is corrected.

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*Note:* Paper submitted in 1980.

# Chapter 8

# Subsurface survey: the use of magnetics in Australian archaeology

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Having identified the presence of a site of archaeological interest, there is great advantage in learning as much as possible about its dimensions and composition without it being physically disturbed. Frequently there are good reasons why a site should not be disturbed, or, if a pilot excavation is proposed, it is desirable that the most profitable location be chosen and that there be some prior knowledge of the structures to be encountered. Instruments have been developed which can measure, from above ground, physical properties of objects and materials which are buried beneath the surface. These measurements can enable the extent of a site to be mapped and frequently facilitate location and identification of objects within the site.

The physical properties which can be measured from above ground and have been used in this application are magnetism, electrical conductivity, density and the velocity at which sound waves or vibrations will travel. The instruments used have usually been initially developed for geophysical exploration but with refinement have been made sensitive to relatively small features such as may be encountered on an archaeological site. Some of the methods are applicable only to sites of technologically complex cultures where large structures were erected or metallic objects used. The method most applicable to Australian prehistory is the magnetic method and it is this which is presently emphasised. The resistivity method has also been used successfully (Stanley, 1978).

Both the instrumentation and methods of fully interpreting measured data are sophisticated and thus tend to be expensive. In the descriptions which follow, endeavour has been made not only to present what can be achieved regardless of cost and skill, but also what useful information can be obtained by a non-technical person with borrowed or hired equipment.

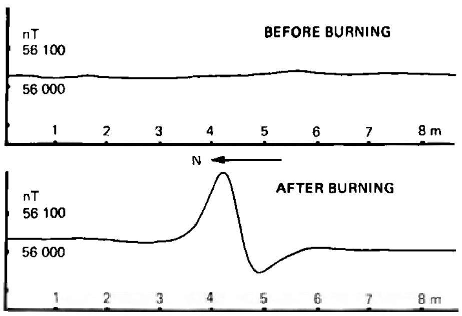
## THEORY

The Earth is a large magnet with a north and a south pole. Objects within the influence of the Earth's magnetic field acquire an induced magnetism of their own. In the case of materials containing a lot of iron this induced magnetism can be quite strong. In practice, most of the materials encountered in an archaeological site contain some iron, although maybe only a few parts per million, and this gives rise to very weak magnetic properties. The intensity of magnetisation $I$ induced in a material is proportional to the intensity of the magnetising field $H$ (the Earth's field),

$$\text{i.e., } I = \chi H$$

The constant of proportionality, $\chi$, is known as the 'magnetic susceptibility' of the material. Its value varies over a very wide range, as can be seen in Table 1 where typical magnetic susceptibilities are listed for a number of materials. Wherever there is a contrast in magnetic susceptibility between two materials (e.g., an object and the material in which it is buried) then there will be a local variation called an 'anomaly' in the magnetic field. This arises because the induced magnetism of the material with the higher susceptibility is greater than that of the other. If we can measure the anomaly associated with a buried object, then we can locate the object.

*Fig. 1*
*Caesium magnetometer profiles measured across the site of an experimental hearth, before burning and after burning. The fire was lit and left to burn overnight.*




In addition to induced magnetism, which is always in the direction of the Earth's inducing magnetic field, some materials exhibit permanent magnetism. That is, they display magnetism even in the absence of a magnetising field and the direction of their magnetism is fixed with respect to the geometry of the object. A common bar magnet or the Earth itself are examples. Some substances containing iron minerals (e.g., some clays) display a relatively high magnetic susceptibility when heated above a particular temperature. Above this temperature they acquire a proportionally strong induced magnetism. On cooling below this critical temperature, known as the 'Curie temperature' (about 560°C), this induced magnetism becomes 'frozen' and the object retains a permanent magnetism. Permanent magnetism acquired this way is known as 'remanent' magnetism. It is often encountered at the site of pottery kilns or of fireplaces (Figs 1 and 2). Because permanent magnetism retains its direction with respect to its host object interesting studies have been made where the direction of remanent magnetism at a site has been measured relative to the magnetic north pole. The fact that the two are not always parallel has provided evidence that the direction of the Earth's field has changed with time (Barbetti, 1972, 1973) or the continent upon which the site is located has moved (Tuzo-Wilson, 1972) or both.

A complicating factor in the application of magnetic field measurement to the location of small, weakly magnetised objects of archaeological interest is that the intensity of the Earth's magnetic field can vary over short periods of time by amounts comparable to the magnetic anomaly of interest. Time variations of this nature (micropulsations) occur most during 'magnetic storms' associated with sunspot activity. Micropulsations can be isolated

from survey data by the fact that they are transient and occur randomly in time whereas the magnetic anomaly of a buried object remains constant. If a survey were duplicated then the field due to the object would remain in position while the time variation would not be reproduced at the same place.

## INSTRUMENTATION

There are several types of instruments used for magnetic field measurement. They are all called 'magnetometers'. They vary in sensitivity, rate at which measurements can be performed and also expense. They usually measure the total intensity of the magnetic field, although an older type, the 'fluxgate magnetometer', measures only the component of the field in the direction along which the instrument is pointed.

The intensity of the Earth's own magnetic field varies with latitude but is typically between 40 000 and 70 000 units. The metric unit adopted is the 'nano-Tesla' (nT), traditionally called a 'gamma'. The magnetic anomaly arising from an object of archaeological interest is added to the Earth's field. The amount added is usually very small. At Australian prehistoric sites it will usually be less than a few tens of nano-Tesla.

The most readily available magnetometer suitable for archaeology is the 'proton precession' type (Fig. 3). Its sensitivity is usually 1 nT and about 3 seconds are required to take each measurement. The proton magnetometer consists of a staff-mounted sensor of volume about 1 litre and a cable connecting this to a small control electronics box which is usually carried about the operator's neck. The cable is provided to remove the sensor from the magnetic field associated with the electronics. For high resolution surveying it is usual for one operator to hold the sensor while the other stands well away (about 3 metres) with the electronics and recording pad. If resolution no greater than 5 nT is necessary then one operator can perform both tasks.

The fluxgate-type magnetometer is directional. This means that all measurements must be made with the sensor pointing precisely in the same direction. This is best achieved by hanging the sensor

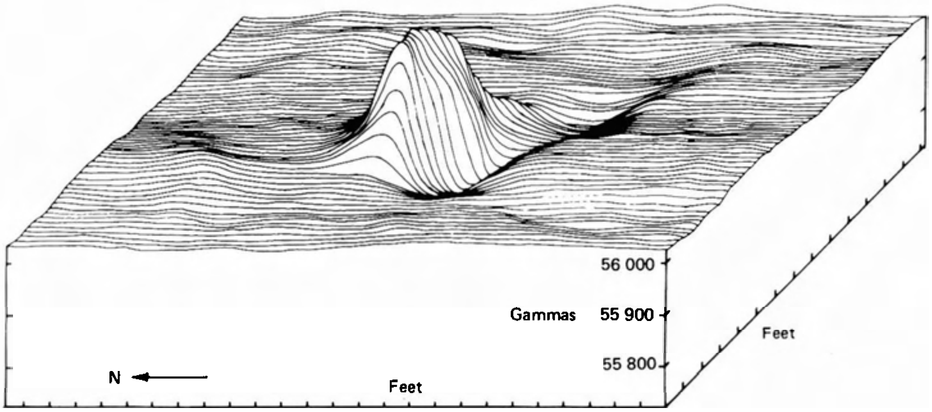



*Fig. 2*
*The magnetic anomaly recorded with a caesium magnetometer 0.5 m above the experimental hearth of Fig. 1.*

*Table 1*

### TYPICAL MAGNETIC SUSCEPTIBILITY VALUES

| *Material* | *Susceptibility* × $10^{-6}$ *(range)* | *SI units (average)* |
|---|---|---|
| Basalt | 250–100 000 | 14 000 |
| Clays | 50–650 | 300 |
| Granite (without $Fe_3O_4$) | 0–65 | 20 |
| Haematite (compact) | 4 000–10 000 | 7 000 |
| Humus | 50–10 000 | 300 |
| Limestone | 0–280 | 25 |
| Magnetite | $7 \times 10^4$–$14 \times 10^6$ | $10^5$ |
| Quartz sand | 0–50 | 20 |
| Sandstone | 0–1 660 | 30 |
| Shale | 0–1 480 | 50 |
| Shell | 0–50 | 30 |
| Slate | 0–3 000 | 500 |






*Fig. 3*
*A proton precession magnetometer (by courtesy of EG&G Geometrics).*

vertically and hence measuring the vertical component of the magnetic field. In a survey it is difficult to hold the sensor sufficiently steady to achieve better than 5 nT or 10 nT accuracy. The fluxgate magnetometer is a compact instrument but being directional and less accurate is not now commonly used.

By far the best magnetometer for rapidly and accurately surveying archaeological sites is the 'caesium vapour' type. This instrument resolves 0.1 nT at a virtually continuous rate. Consequently it lends itself to rapid, automatic digital recording and computerised data processing. Moreover, it can be operated with two sensors simultaneously. If one of these is held stationary while the other is used to traverse the site, then time changes in the Earth's magnetic field may be subtracted. As micropulsations effect both sensors together, then substraction of the base station measurement from the mobile leaves only the magnetic field which is due to a buried object. (The Earth's field itself is also subtracted by this operation.) While the caesium magnetometer has the best characteristics for rapid and precise surveying, it is an expensive, sophisticated instrument requiring an experienced operator.

## SURVEY PROCEDURE

The general objective of a magnetometer survey is to measure magnetic field values over a systematic grid covering the area and to identify anomalies encountered. It is usual to peg out parallel traverse lines and to record field values at constant distances along these lines. Before pegging such a grid line, spacing and sample intervals must be selected. The closer together that measurements are made, the more information is obtained and hence the easier it is to interpret. However, the trade-off for better grid coverage is the increased survey time and hence a reduction in the area that can viably be mapped. In order to compromise it is usual to consider the dimensions of the smallest object to be resolved. If the operator is to be sure that his survey will not miss such an object by taking measurements too far to either side then his sample interval must be no greater than the dimension of the object in the direction of traverse. Similarly, traverse spacing must be no more than the dimension of the object in the direction perpendicular to the traverse. In practice, the area of magnetic influence of an object (its magnetic anomaly) will be greater than the object itself, so the rule of thumb given has this margin of error. Of course it is one requirement to ensure that a magnetic anomaly will be located by a single measurement, but if it is also to be mapped then several measurements over the anomaly must be recorded.

Consider that a humus rich ($\chi = 100 \times 10^{-6}$ SI units) midden site, 20 by 50 m, overlying sand ($\chi = 10 \times 10^{-6}$ SI units) is to be surveyed with a view to locating magnetised clay fire hearths 1 by 1 m. If a sample interval of 1 m was used the midden itself could be adequately mapped and its boundaries located to within perhaps half a metre. However, each fire hearth would be indicated by only a single measurement differing from those around it. It is unlikely that the hearth would be recognised from this single recording. If the hearth is to be reliably identified then the sample interval should be reduced by at least five, i.e., to 20 cm. By a similar argument the line spacing would have to be no greater then 1 m and preferably the same as the sample interval along the traverse.

Related to sample interval is the height at which the sensor should be held above ground. The intensity of a magnetic anomaly will decrease with the cube of the distance from the source, i.e., to double the sensor distance from the anomaly source will reduce the value of the anomaly by $2^3 = 8$ times. Also, to increase the height above the ground means that the sensor will become as sensitive to anomalies to the side, as those directly beneath. However, to hold the magnetometer too close to the ground makes it over sensitive to magnetic sources right on the surface, at the expense of masking anomalies originating beneath the surface. In some geological environments there is a tendency for small quantities of chemically stable iron minerals to concentrate at the ground surface (Graham & Scollar, 1976). There is no firm rule but a sensor elevation equal to the sample interval is usually appropriate.

The inverse cube relationship between distance and intensity can be used to advantage when a caesium magnetometer with two sensors is available. Measuring the difference between two such sensors, one of which is, say, 0.5 m above ground and the other 1.5 m, enables the anomaly arising from a near surface archaeological source to be enhanced from any anomaly arising from a deeper geological source. Moreover, this difference measurement eliminates temporal variations in the Earth's magnetic field.

In performing a magnetometer survey it is imperative to remove all magnetic objects worn by the operators or located near the site. Anything made of iron, including buckles, watches, boot nails, ball-point pens, etc., cannot be worn or carried within 3 or 4 m of the magnetometer sensor. Clear the site of steel cans or other items of junk containing iron. If a sharp change occurs in magnetometer readings look about for a concealed nail or can that may be the source. The greater the mass of iron, the wider will be its range of magnetic influence. Steel fences, motor vehicles, water tanks, etc., will effect the magnetic field for up to 100 m. So too will high-tension power lines. The ranges of some common magnetic influences are shown in Table 2. If a magnetometer survey is to be reliably interpreted, the operator collecting the data must be continuously alert for non-archaeological sources of magnetic anomaly.

*Table 2*

### RANGE OF MAGNETIC INFLUENCE OF COMMON CULTURAL INTERFERENCE*

| *Interference from:* | *Distance (m)* |
|---|---|
| Large truck | 100 |
| Power lines, high voltage | 75 |
| House | 50 |
| Motor car | 40 |
| Steel telegraph post | 30 |
| Steel fence post | 10 |
| Steel food can | 4 |
| Small nail | 1 |

* The distances given refer to the approximate distance from a magnetic object at which the magnetic influence is below 1 nT.

## PRESENTATION AND INTERPRETATION

There are many ways of presenting data consisting of a parameter measured at different places on a grid. One of the most common is the contour map, where continuous lines join all points having the same value of the measured parameter. Such maps are relatively tedious to prepare and are only really effective when variations in the measurements occur smoothly and are of similar size and amplitude. This is frequently not the situation when high-resolution magnetic surveys are applied on an archaeological site. Imagine a contour map of height above sea level in a mountainous region. Information recording the height of ant hills is totally lost in

this presentation. Similarly, a magnetometer survey may have 'mountainous' anomalies arising from deep geological sources and superimposed upon these may be the weak, local anomalies of interest to the archaeologist. In this situation it is advantageous to present the data as a projection of stacked profiles.

To achieve this each traverse is plotted as a profile. Magnetic field values are plotted on the vertical axis and distance along the traverse plotted horizontally. Because the anomaly is only a few tens of nano-Tesla on a base field of about 50 000 nT it is necessary to subtract a base field value from all measurements. For example, if the values measured during a survey range between 50 050 nT and 50 080 nT then it would be appropriate to subtract 50 050 from each reading, and the vertical axis would then extend over say 0.40 nT. In any one survey the base field to be subtracted should be the same for all traverses. The origin of each profile is then the point where the traverse distance is zero and the magnetic field is 50 050 nT. This point is called the 'profile reference point'. Having plotted the measured values of each traverse, a smooth curve is then drawn joining all points. Next an isometric plan of the survey site is drafted on tracing paper. A horizontal line at the front of the plan represents the base field of the first traverse. An axis is then drawn obliquely from one end of this line, usually at an angle of 60°. The two lines intersect at the reference point of traverse 1. The reference points of the remaining traverses are scaled off along the oblique axis at distances representing the line spacing. The scale along the oblique axis should generally be the same as the horizontal one. Next, the first profile is made to underline the isometric plan in preparation for tracing. The profile reference point is located under the appropriate reference point on the plan and the horizontal axis aligned with the plan. The magnetic field profile is then traced. The second profile is similarly aligned parallel to the first but with its reference point correctly located under the appropriate point on the plan. Adjacent profiles such as these will generally have a similar appearance but with some variations. Where the second profile appears to go 'behind' the first it is common not to trace this portion. The remaining profiles are 'stacked' in order by the same procedure (Fig. 4). The result is an image which represents the magnetic field variations in three dimensions.

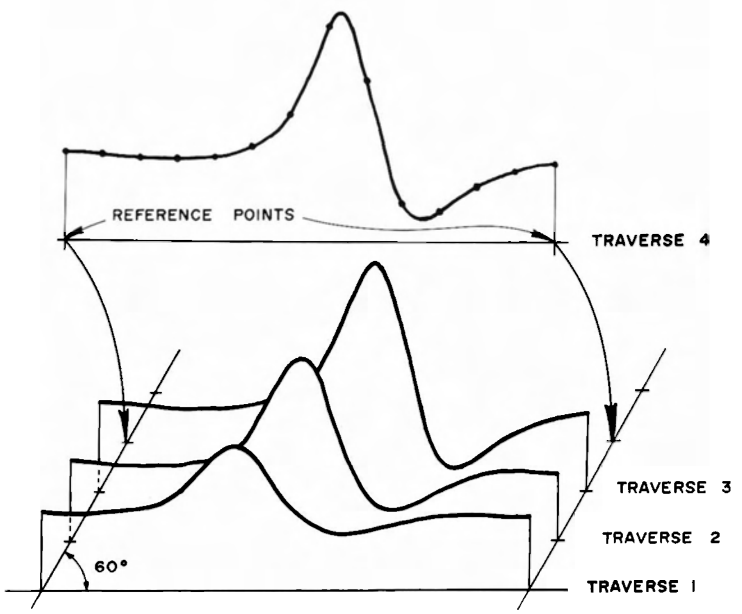
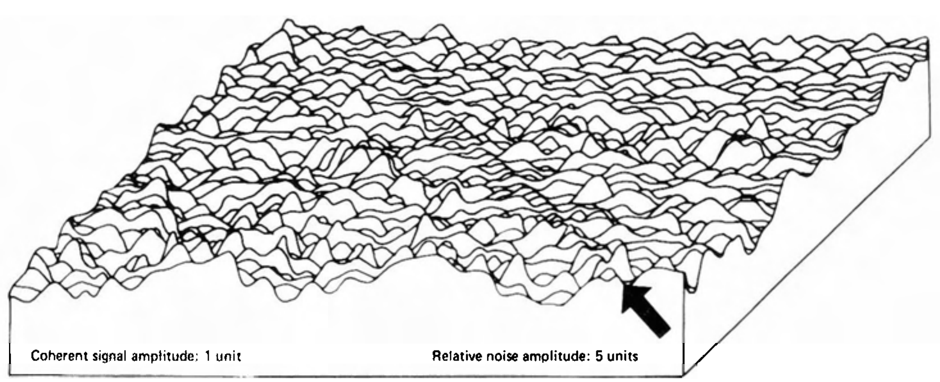



*Fig. 4*
*Preparing an isometric stack of magnetic field profiles. Each profile is drawn separately, then traced onto the stacked picture in order, with traverse 1 at the front.*

The principal advantage of presenting data in this stacked profile manner is that it is a simple graphical operation which enhances spatial anomalies (Fig. 5). That is, anomalies common to several adjacent profiles become clearly apparent by eye, while anomalies which are not coherent between profiles, i.e., random time variations in the Earth's magnetic field, become invisible (Stanley, 1976). Large anomalies arising from deep geological sources will give the appearance of a steep slope or fold in the stacked image and this will not usually be confused with local anomalies of archaeological origin.

The interpretation of a magnetic anomaly in terms of the exact position, depth and geometry of the source body can be a highly involved mathematical operation. Geophysics texts cover this aspect of magnetic surveying but the topic can be avoided in most archaeological applications. Because the source of the magnetic anomaly is generally very shallow compared with its horizontal dimensions and its magnetism is very weak it is usual to assume that the area covered by the magnetic anomaly is approximately the same as the area of the source. There is one complicating factor, the Earth's magnetic field is inclined upwards towards the north (in the southern hemisphere) and hence induced magnetic anomalies will tend to be high at the north end and be low at the south end of the source. In the case of remanent

*Fig. 5*
*Synthetic data demonstrating the visual signal enhancement of a coherent signal buried in temporal or short wavelength spatial noise. Unfiltered analog field records may be rapidly and conveniently stacked by tracing.*



magnetism the low will be in the position that was south at the time of cooling below the Curie temperature.

## EXAMPLES OF MAGNETIC SURVEYS

Figure 6 shows a stacked profile image of a proton precession magnetometer survey over a shell midden at Stuarts Point on the mid-north coast of New South Wales. The Stuarts Point midden consists of a long deposit of shells, humus and ash overlying thick beach sand (Connah, *et al.*, 1976). The mean magnetic susceptibility of 16 samples of midden material was 140 × $10^{-6}$ SI units, while the mean of 20 samples of the underlying sand was 20 × $10^{-6}$ SI units. The magnetism exhibited by the midden was predominantly induced and the amplitude of the anomaly measured 20 cm above ground was 25 nT. Measurements were recorded at 25 cm intervals along the traverse and a line spacing also of 25 cm was adopted. To improve the appearance of this image, each profile was smoothed by taking a running average of 30 measurements at a time and plotting these 'filtered' data and by filling in extra profiles interpolated between those actually surveyed.

A second example (Figs 1 and 2) shows the magnetic anomaly associated with a fire hearth. These data were recorded with a caesium magnetometer which enabled a sample interval of a few millimetres to be employed. Line spacing was 5 cm and the sensor elevation was 50 cm. The magnetic anomaly in this example arises from permanent magnetism. The soil originally contained a trace of iron oxide (haematite), which contributed a relatively low magnetic susceptibility and no permanent magnetism. In the presence of the oxygen-deficient fire some of the haematite was reduced to the more magnetic minerals magnetite and maghemite. In addition these newly formed minerals were heated above the Curie temperature (about 560°C). On subsequent cooling below this temperature remanent magnetism was retained. Note that the magnetic anomaly is clearly 'high' to the north and 'low' to the south. This is because the direction of the remanent magnetism is north-south. One must always be aware that a low magnetic value will occur to the south of an induced magnetic source and in the case of remanent magnetism the low will be in the position that was south at the time of cooling. The Stuarts Point anomaly shown in Fig. 6 is induced but it does not display the low field value. This is because the traverses were made east–west across the midden and the southern end was not mapped.

In conclusion, subsurface survey based on magnetics is practicable in the context of hunter-gatherer sites. At the time of writing, however, such survey has been very little used in Australian prehistoric archaeology. It is to be hoped that it will be used in the future because it has a number of possible applications. Perhaps most important of these would be the detection and mapping of hearths in extensive occupation sites. For this task the caesium magnetometer is obviously the best suited but less detailed results can be achieved using the proton precession magnetometer and investing much more time in the actual field survey. I am always willing to advise on the use of these instruments and may, on occasion, be willing to collaborate with field archaeologists by conducting a subsurface survey with the University of New England's caesium magnetometer, which can produce highly accurate results very quickly.

*Fig. 6*
*A stacked profile image of a proton precession magnetometer survey over a prehistoric shell midden at Stuarts Point, NSW.*

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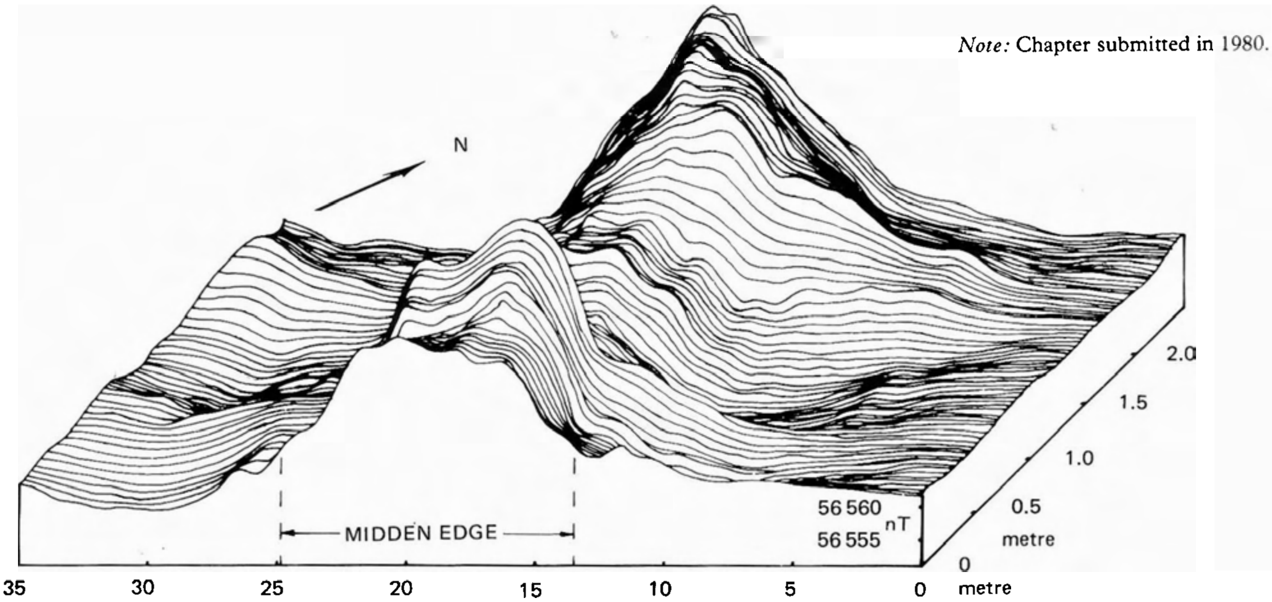
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*Note:* Chapter submitted in 1980.



# Chapter 9

# Recording prehistoric art

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In this chapter on recording rock art I deal with the problems of recording two main types of rock art: (1) engravings and poundings where the pattern is one of relief and the pictures were apparently produced by removing material from the rock surface; and (2) drawings, stencils and paintings where material was added to the rock surface. I shall not give much space to the essentially surveying problems of recording stone arrangements and earthworks (but see Chapter 4) though some of the techniques discussed are relevant to such problems. The chapter has a set of instructions or recipes which explain how to use various techniques. Any work is potentially destructive and must not be attempted without a permit from the relevant authority (see Chapters 1 and 3).

Recipes are useless or positively harmful unless accompanied by some thought about the aims of the exercise—so there is an introductory discussion. The recipes are designed around two constraining factors; what is wanted from the recording—a qualitative consideration—and a balance between desired standards of detail and accuracy and the resources of time and money. I try to indicate the method which is at the moment (in 1978) the best available—as well as a technique which produces the best results for least effort and expense.

A recording is one which contains as much information as the original. Adequacy is an ideal to be aimed for (like objectivity), an ideal which is unlikely ever to be achieved. It can be separated into two vectors: completeness and accuracy. Should a limited amount of time be spent in recording the whole or in recording a part with the utmost care? I am not sure it matters much except in that a recording of a part of a site can be misleading if it is taken for the whole site; an inaccurate recording can be misleading if it is taken for an accurate one.

So we are aiming for *completeness* and *accuracy,* to which must be added *efficiency.* Time and money are always limited; in some cases a little accuracy or completeness should rightly be sacrificed for economy—where the effort concerned could be better spent elsewhere. People who have got so far as to read this chapter of this book will have heard one simple fact so often that they may suffer from extremes of boredom if they hear it reiterated. The simple fact is that suitable methods do not exist independently of themselves. There is no one way to record rock art, as there is no one direction in which cars should be driven, no one way of walking or cooking. The best way to poach an egg is not also the best way to fry bacon or toast cheese.

In recording rock art there are two difficult bits, and the rest is easy. The first difficult bit is to work out what exactly you are trying to do—Why do you want to record this or that particular phenomenon? What for? What particular pieces of information which are present in the field do you wish to take away with you? Answers like 'I am going to record it perfectly, I need *all* the information' are false, naive or greedy. The information contained in the smallest, simplest relic is infinite in extent, and can only be recorded with an infinity of effort, so any attempt to produce a *really complete* recording is doomed to failure. Far better to cut down the aims to something like: 'make a reproduction such that unaided human senses cannot distinguish the original from the reproduction'. It is quite feasible—but expensive—to produce reproductions of prehistoric art which are good enough to fool most people—though a residual acrylic odour or a hollow sound when struck might reveal the reproduction as plastic-bonded, not iron-oxide-bonded, sandstone. That sort of work is done by museums for exhibition purposes. At the other extreme is the minimum information which is worth recording. That minimum tells us what is there, and how to get to it. What is there, of course, involves a description and therefore a classification. A sketch, photograph and accurate map reference is the very minimum. Various state and federal bodies have been developing *site cards* for accurate and usable minimum recording. A good site card system allows the recording of much more than the minimum information. The first great difficulty about recording rock art is to determine what you are trying to do. If you know—precisely and in detail—*why* you are trying to do it, that is, what you are trying to do it *for,* then it will be quite possible to draw up specifications of what is required of your recording. Once you know that, it is very easy indeed to devise a way of producing the desired product—though of course practical constraints on time or money may frustrate the exercise.

In my experience the reasons to record rock art come in three main groups: the scientific, the artistic and the managerial. In the *scientific* or archaeological group, information is to be extracted from a set of prehistoric artefacts. The information derived will be used, analysed and interpreted to contribute to the knowledge of prehistory. There is a growing body of literature about means of extracting prehistoric information from rock art (see, for instance, Anati (1977); Clegg (1977); Maynard (1977)). The end product is an academic paper—leading to a synthetic book. The aim of the *artistic* or humanitarian recording of prehistoric art is to do justice to it; to encapsulate it somehow in a form which allows appreciation. Coffee-table books, calendars, film and television, museum exhibits—perhaps even tourist tea-towels—are the end products of this sort of recording. The *managerial* reasons are so that those people who have the task of conserving, managing, protecting, and interpreting the artefacts have the necessary data. It is rare for a recording made for one purpose to be of any use for the other. There is also the impossible task of the *salvage recorder,* where an artefact is about to be destroyed and the aim of the recording exercise is to preserve for posterity. In that case, the recorders must either arrogantly assume

that their personal aims are all that need to be fulfilled or attempt somehow to predict in detail what posterity will require of the recording.

The second great difficulty is that of perceiving the art to be recorded. Cameras, for instance, are very flexible machines which are highly competent at depicting whatever they are pointed at—but they cannot know for themselves where to point. We have to be able to see the art before we can record it. Often one may notice on a photograph some stencil or other feature which has not been seen in the field; far more commonly a field inspection reveals things which do not appear in photographs. The problem of perceiving the art to be recorded is caused partly by the often faint and eroded nature of the art, partly by our human tendency to see those things which we know are there and be blind to those things of which we are ignorant. In the recipes which make up the body of this chapter, I suggest techniques for dealing with this problem. The single essential technique is one which forces the recorder to pay careful attention to the art as a preliminary to any attempt to record it. The only way I know of looking hard at an object is to draw it—sketch it, freehand, without looking at the paper (you are supposed to be looking at the rock, not at your paper). By making a sketch you are forced to pay enough attention to the rock to see what is on it. Once you can see (or feel) the art you are interested in recording, *and* you know exactly and in detail what functions you wish the recording to fulfil, then it is quite easy to work out the limits of accuracy required of each bit of information and which bits of information are wanted. After that there is no problem about devising a way to do the recording.

## RECORDING FOR RECORDS

People who have the task of protecting sites need to know what is there and where it is. The task is not neatly tied to a scientific aim; the records must be available for any number of different purposes from providing archaeologists with a list of likely study areas to evaluating the damage which would be done if an area were flooded or turned into a suburb. The task is not the simple one of answering scientific questions nor that of registering pretty pictures suitable for museum exhibitions or coffee-table books. We cannot dismiss the task simply as impossible on the grounds that a complete record is required. One of the constraints on any library of site records is that there should be some consistency in the amount and quality of information; even if the information is computer-stored it is still convenient to think of a system as site *cards* where a filing system has one card for each site and each card contains a description of the site which, without being *complete,* is still adequate for protecting and inventory purposes. Site cards are necessary for all sorts of relics' records but perhaps most clearly so for rock art.

## RECORDING FOR PUBLICATION

Not every record made in the field will end up in print but there is no harm in considering any special factors which need to be taken into account in publishing and filing. In my short career of getting articles into print I have been amazed by what can happen between the writing and the printed page.

The difficulties can quite often be attributed to *lack of communication.* Different publishers have different house styles and different requirements for manuscripts. Some publishing houses issue printed guidelines for authors, and these should be studied carefully before starting to prepare a manuscript. Write to the publishers and ask for their guidelines if you do not already have them. In any case, to avoid misunderstandings and disappointments later, it is important to discuss the illustrations, especially the use of colour, formats, and sizes, with the publisher, editor and book designer while the manuscript is still in an early stage of preparation. Make sure the publisher knows in advance roughly how many, and what kind of, illustrations you wish to include, and their approximate sizes.

The printers work from the photographic *print*—no need to let the negative out of your clutch. But get two prints made—one to keep and one for the editor.

For colour plates the printers work from a transparency, not a colour print or negative. Since excellent colour prints can be made from transparencies and we tend to need transparencies for use as slides in lectures anyway, I am inclined to give the colour negative film a miss.

Unless you really know what you are doing as a photographer, do not expect to get even a perfect 200 × 250 mm (8 in. × 10 in.) colour print from 35 mm transparencies; coffee-table books need large-format cameras. But an ordinary quarter-plate (90 × 130 mm) looks quite big in a book and 35 mm slides usually work well up to 130 × 180 mm. So you can file quarter-plate prints and submit them to the editor, but guard the transparencies till you are quite sure they are needed and will be looked after. The advantage of using 90 × 130 mm colour prints as standard is that they can be cheaply, consistently and quickly produced by the popular photographic processors.

## BASIC METHODS

We have two ways of recording prehistoric pictures: the use of writing and numbers, and graphic means where the pictures are described in pictures or diagrams. It might seem at first that all recording should be by graphic methods but the enormous success of Edwards' comparison of percentages of motifs at rock engraving sites in South and central Australia (Edwards, 1966) and Wright's analysis of proportions of human figures among Pilbara engravings (Wright, 1968) has demonstrated that symbolic, as opposed to graphic, methods are ideal for some purposes.

### Method 1. Site location

Most states have site record systems including standard site cards and instructions about how to fill them in.

*Ingredients*

Permit
Blank site cards
Instructions for completing cards
Maps, compass, etc.
Pen, pencil, etc.

*Method*

Fill in site card as per instructions.

Most Australian states have legislation for the protection of relics. It is necessary to obtain a permit from the relevant state authority to use techniques described in this chapter.

### Method 2. Edwards' percentage comparison

*Prerequisite*

Method 1

*Ingredients*

Paper, pen, pencil, calculator.

*Method*

(a) Look at range of motifs.
(b) Classify them into usable categories, e.g., animal tracks, lines, circles, pictures of animals, miscellaneous.

(c) Count all the examples of motifs in each category in the area chosen.
(d) Calculate the percentage that motifs of each category form of the whole assemblage of motifs.
(e) Take a few photographs which describe the motif type and range.

**Method 3. Hand-stencil measurement**

*Prerequisite*

Method 1

*Method*

In a site with a dozen stencils it should be possible to ascertain whether, for instance, the stencils were made from one hand twelve times or by up to twelve different hands. But in such a study, the minutiae and consistency of measurements are likely to be critical; the measurement would have to be made on the site from the real stencils, not indirectly from tracings or photographs.

1. *In your study*
   (a) Research to discover which measurements of hands are relevant to the individuality of hands.
   (b) Devise a consistent way of defining and measuring the dimensions from stencils in the field.
   (c) Draw up a table itemising the measurements to be taken on each stencil.
2. *In the field*
   (a) By sketching and photography define and label each stencil.
   (b) For each stencil take the measurements and fill in the table.

So what is taken back for analysis is a set of tabulated figures which refer to individual stencils; a picture defining each of the measured stencils and the usual relocation information. Most of the recorded information is numbers written on a table.

Words and numbers are only useful so long as everyone is agreed on what each means. We need an agreed classification system. It is quite useful to use the words 'kangaroo' or 'dinosaur' or 'sack of potatoes' to describe the shapes of marks on rocks and such terms may be so descriptive that we can all understand what shape is being described. If the shape is labelled with a word which can refer to real-world objects, however, then the term may be misunderstood as stating that the pattern on the rock is a *picture of* the real-life thing to which the label can refer. I have introduced the usage of prefixing an exclamation mark to the label when indicating that this label is only intended as a name for the shape of the mark, thus: !fish, !seahorse, !hermaphrodite, !jellyfish (Clegg, 1978).

Recently a lot of work has been done on methods of describing rock art which are objective enough to reach the same results when used by many people on varied occasions, and Lesley Maynard, who has done most of the work in this area, contributed an important paper, 'Classification and terminology in Australian art' (Maynard, 1977), to *Form in Indigenous Art* (Ucko, 1977). The following abridged version of that paper is included here with her permission.

**Method 4. Description and classification of Australian rock art**
(abridged from Maynard, 1977: 387–403)

The function of a typology is to state, in clear terms, the range of phenomena present, and at the same time divide these observed phenomena into several categories so that a system of variations within the range is organised. It is necessary, of course, that the names given to these divisions be unambiguous, well defined and uniformly understood and used.

In this system, discrete characteristics of the rock art are separated into traits which can operate independently in describing an individual figure. As an example, consider a painted figure which includes two different colours. Instead of a single label—'bichrome'—this figure would be the subject of a multi-trait description which would include the two colours as traits, along with other traits designating aspects of the figure's technique, form, motif and other special characteristics.

There are five levels in the descriptive process—Technique, Form, Motif, Size and Character. An individual figure can be described in terms selected from all five levels (see Tables 1–5).

*Technique* (see Table 1)

This is the purely technical aspect of a carving or a painting, the method by which marks are put on a rock surface, and a description of the shape, size and texture of these marks, rock carvings or rock engravings or petroglyphs. These latter terms refer to marks made by subtracting from a rock surface. In the Australian context 'engraving' should be designated a general term, synonymous with 'rock carving' or 'petroglyph' (which are used occasionally), and those terms used to describe any process involving subtracting from a rock surface to make a design.

*Friction, percussion, rotation* (A, B, C in Table 1). There are only three basic methods of using an implement (including fingers) to mark rock: pushing it horizontally over the surface (friction), pressure in the vertical axis by means of percussion and rotating a drill in one place to grind a hole.

*Scratched, abraded, groove, rubbed, rubbed area* (Ai, Aii, Aiii in Table 1). The first two subdivisions under carvings produced by friction, scratching and abrading, produce a continuous groove. The term 'scratched' is used when an engraving consists of shallow, finely incised lines which are almost certainly the result of running a sharp instrument once over the rock surface. There is no difficulty in distinguishing these from 'abraded' grooves which are the result of repeated friction along the same line. The shape of an abraded groove will vary according to the implement used, the type of rock and the technique of the operator. Abrasion with a sharp tool tends to produce the common V-shaped groove in most rocks.

Sometimes, instead of a groove, an area of rock surface is rubbed smooth. This technique is usually found in conjunction with others—e.g. a pecked outline with a rubbed area inside it.

*Pounded, pecked, drilled, pit* (Bi, Bii, C in Table 1). There are two definite types of percussion-treated carvings which are found in Australia. Mountford observed Aborigines in Central Australia making designs by pounding the surface of patinated rocks with lumps of stone held in the hand. This direct percussion bruised the outer coating and produced shallow impressions which broke through the patination (usually dark coloured) and exposed the unweathered (light coloured) inner surface (Mountford, 1955). There are also many prehistoric examples of carvings apparently made by this method, including many sites in the Pilbara area of Western Australia (Wright, 1968). The individual pits are shallow and distributed in a manner which suggests the lack of fine control resulting from direct percussion. The edges of solid figures made by pounding are rather diffused.

The result of this hammer dressing is quite different from the ancient carvings found in Central and South Australia, which consist of deep nicks in the rock surface (Mountford & Edwards, 1963).

*Table 1*

## ROCK ART TECHNIQUE

| | |
|---|---|
| **Rock carvings or rock engravings or petroglyphs** (subtractive process) | |
| A. *Friction* | |
| i. scratched (single stroke)<br>ii. abraded (repeated friction) | makes a groove (V-shaped, U-shaped, etc.) |
| iii. rubbed (broad surface) | makes a rubbed area |
| B. *Percussion* | |
| i. pounded (direct percussion)<br>ii. pecked (indirect percussion) | makes a pit (round, oval, deep, shallow, etc.) |
| C. *Rotation*<br>drilled | |
| **Rock paintings or cave art or pictographs** (additive process) | |
| D. *Mechanical*<br>i. stencil<br>ii. imprint | (red, yellow, black, white, etc.) |
| E. *Delineated*<br>i. painting (wet)<br>ii. drawing (dry) | |

&: used to join descriptions of different parts of one figure which are done in different techniques—e.g. Bii & Aiii.

/: used when one technique is superimposed on another—e.g. Bii/Aii.

(From L. Maynard, Classification and terminology in Australian rock art. In: P. J. Ucko (ed.), *Form in Indigenous Art*. Canberra, Australian Institute of Aboriginal Studies, 1977, p. 391; by permission.)

These engravings are more precise than the shallow poundings, and it seems very likely that they were made by indirect percussion, using a sharp-pointed tool which was deliberately placed in position and then hit with a hammerstone. The term 'pecking' has often been used to describe these deep carvings; I propose 'pounded' and 'pecked' to distinguish carvings apparently executed by direct and indirect percussion, respectively.

Although one cannot demonstrate, in every single case, whether direct or indirect percussion was used, it is still useful to distinguish between the two types because there are many more definite cases than indefinite. An ambiguous rock carving could still be described by the appropriate term from the next highest level in the hierarchy—in this case, 'percussion'.

A 'pit' is the result of any percussion or rotation. It is a small depression in the rock surface, roughly circular or elliptical, and deep or shallow, depending on the circumstances of its manufacture.

*Rock paintings or cave art or pictographs.* These terms refer to marks made by adding some coloured material to rock surfaces. 'Pictograph' has been used in America to describe all such figures, but it has never been popular in the Australian literature. It is, however, difficult to think of an alternative term which applies to the dry crayon drawings as well as to paintings done in mixed ochres. I suggest the use of all these as general terms, without rigid etymological control. I regret the later use of 'painting' for a specific technique, but in this case there is no satisfactory substitute in common use.

*Mechanical, delineated, stencil, imprint, painting, drawing* (Di, Dii, Ei, Eii in Table 1). There is a basic difference between a figure which is delineated on the surface by the artist and an object which is represented by the mechanical processes of stencilling and imprinting. A stencil consists of a blank space surrounded by a border of splattered paint. The quality of the margin shows that some object has been held against the wall so that a negative impression of its shape will remain when paint is sprayed around it. The mark made by pressing an object such as a hand which has been dipped in wet paint against a rock is quite characteristic.

By contrast, delineated figures are composed of coloured lines or solid areas which appear to have been applied under direct manual control without any other aids. When the ochres have been ground up and mixed with a liquid before being applied to the rock surface, the painted area is evenly coated with colour. When dry pigment is rubbed on the rock like a crayon the high spots of the surface are more thickly coated than the low spots, giving a streaky effect to the drawing.

It is always possible that more than one technique will be used to make up a single figure. The same terminology can still be used, with special punctuation to represent the combination of techniques. In Arnhem Land, some hand stencils are decorated with painted designs inside the margin of the sprayed surround. They would be described as Di and Ei (see Table 1). The pecked outlines of some carvings in the Sydney area have been subsequently abraded, which could be shown as Bii/Aii in a formal description (see Table 1).

*Form* (see Table 2)

There are many words which refer to the visual organisation of the marks which make up a figure, such as 'form', 'composition', 'treatment', 'design', 'pattern', 'motif' and even 'style' (as used by McCarthy). I have preferred the term 'form' to describe the organisation of dots, lines and masses which comprise individual figures. The same criteria of form apply to all figures, regardless of technique.

I do not intend that this section of the terminology should be capable of describing every aspect of the appearance of a figure. According to the scheme given in the diagram (Table 2),  and  have the same form—they can both be described as 1c, 2c, 3a. Discriminating between these figures is reserved for the next section of the terminology, Motif. On the other hand,  and  are different forms—the latter is distinguished from the previous description as 1c, 2c, 3b, 4ciii.

The arrangement of Table 2 under the heading 'Form' exploits the logical possibilities of two-dimensional visual organisation in Aboriginal art. A figure may consist of a group of discrete pits or grooves or dabs of colour, associated so that they form one unit but with nothing to take the description any further. Such a figure would be registered simply as 'scattered marks' or as 1a in a coded description. A line (1b, 1c in Table 2), on the other hand, may enclose an area, or not, or form a partial enclosure if there is only a small gap

between the ends—2c, 2a and 2b respectively. Three kinds of line are distinguished—a row of marks with small spaces between them (1b), a continuous line with no division (1c) and the term 'band' (1d), which describes a thick line which is made up of more than one row of pits, or more than a single stroke of paint. Although it is thicker than a single line, a band is still a line having length and direction rather than a solid area. A solid area (1e) is a continuously treated surface which is more bulky than a line or band. It cannot enclose an area within itself—anything inside its margin would be an infill. An infill (3b) is any mark found within the boundary of a figure. The infill may consist of scattered marks, lines or solid areas of colour or engraving (4a–4f in Table 2). 'Partial solid area' is used when only part of the area inside the outline is thus treated. A few subheadings, describing common interior patterns have been included. 'Dots' are roughly circular, 'dashes' are short lines, 'stripes' are lines parallel to the long axis of the figure, 'bars' are at right angles to the long axis, 'concentric' lines follow the course of the outline.

If it is desirable to present a complete description of form as a continuous written statement, special punctuation can be used to organise the elements, as shown in Table 2.

However, a more convenient way of using the system for fieldwork or research is in a column diagram (Table 6). This diagram constitutes a way of registering all the features of a figure's form. I envisage that it could be used in any situation where it is necessary to describe a group of figures—e.g. in fieldwork, as part of the process of recording a site; or even, in some circumstances, as a substitute for scale drawings; in subsequent processing, as part of numerical analysis; and occasionally in the finished publication, if it was desired to present such a detailed description.

It is also necessary to have shortened versions of these formal descriptions because it is not convenient to refer always to a 'red continuous line, encloses space, interior infill, red continuous line stripes/yellow solid area'. The obvious abbreviation, for ordinary usage, is 'red outline with red stripes and solid yellow infill'. I therefore propose the following list of terms for describing form, which are derived from the larger system, to be used in circumstances when it is necessary to describe figures as briefly, but accurately, as possible:

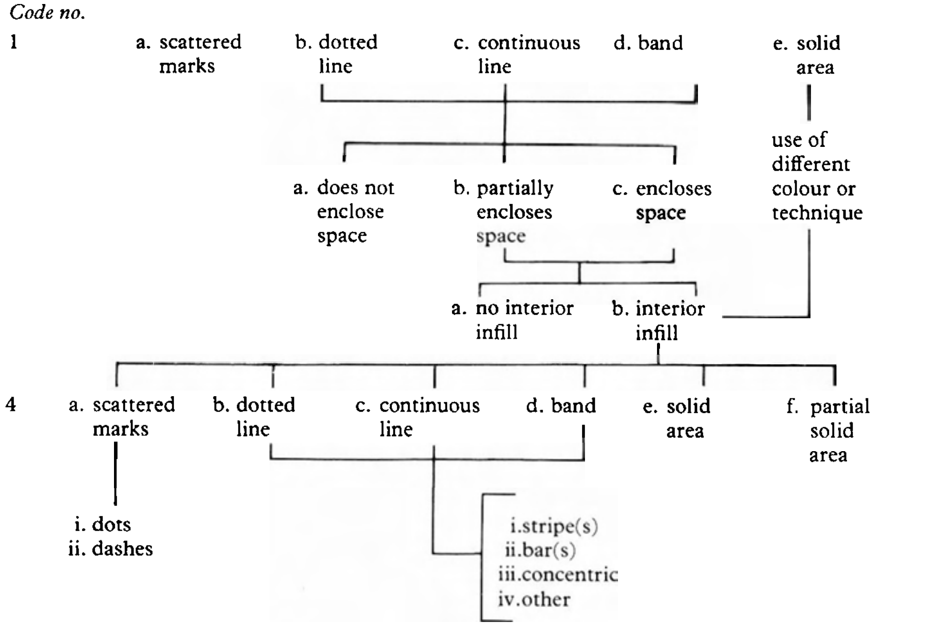
Group of scattered marks (1a)
Dotted line (1b, 2a)
Line (1c, 2a)
Band (1d, 2a)
Dotted outline (1b, 2c)
Outline (1c, 2c)
Thick outline (1d, 2c)
Solid figure (e)
} with infill; with dotted infill; with striped infill; with red stripes and solid yellow infill

These terms can be combined with techniques—'abraded outline', 'pounded band', 'pecked solid figure' (McCarthy's 'intaglio'). The various colours of paintings and drawings can be inserted at this stage in the descriptive system.

I do not claim to have eliminated every element of value judgement from the description of form. It would be nice to be able to do so, but it is probably impossible except perhaps by using a series of mathematical definitions—e.g. a figure is a band rather than a solid area when its length = more than 5 times its width. Such a system would be very clumsy. My aim is to compose clear definitions of terms and an organisation which will cut individual differences in judgement to a minimum level while still maintaining a workable system.

*Table 2*

**ROCK ART FORM**




,: listing the aspects of a figure



: 1c, 2c, 3a.

;: joining description of form to descriptions of technique, motif and size



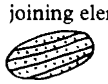
: Bii; 1b, 2c, 3a; NF, circle; 10 mm.

&: joining descriptions of different parts of a figure
(): enclosing the description of one part of a figure



: (1c, 2c, 3a) & (1c, 2a).

/: joining elements which are present in the same part of a figure



: 1c, 2c, 3b, 4ai/ci.

X: indicates multiples of elements comprising a single figure



(From L. Maynard, Classification and terminology in Australian rock art. In: P. J. Ucko (ed.), *Form in Indigenous Art*. Canberra, Australian Institute of Aboriginal Studies, 1977, p. 394; by permission.)

This whole system is, however, proposed purely as a basic classification of Australian rock art—not as a prescription for fieldwork methods or detailed analysis. The 'mechanical' procedures described here (coding and punctuation systems) are intended only as examples. Each worker is bound to design his or her own methods to suit his or her aims and research material and make individual decisions about descriptive procedures. For example, in the case of partly faded or washed-out paintings, one would have to decide whether to describe the figure exactly as it now stands, or as one may reasonably deduce the artist left it.

*Motif* (see Table 3)

As well as being composed of lines or dots or solid areas, a figure also has a shape, i.e. the space occupied by, and the configuration of, the lines or dots, or whatever marks make up that particular figure. Shape is independent of form (as used in the previous section of this terminology). In any body of art, certain shapes tend to recur.

It is convenient to give names to these recurring shapes. When the art is prehistoric the name can only be suggested by the appearance of the figure. My use of the name 'kangaroo' for a particular figure therefore implies only that the figure reminds me of a kangaroo. It is convenient to use this name in order to distinguish this figure from others which remind me of emus, fish, human beings, boomerangs and other familiar objects. The term which I have used for these shape-categories is 'motif'. A motif is a recurrent visual image which has a particular arrangement of components. The precise shape of individual figures which have the same motif can vary to a certain extent, but their basic visual organisation remains constant.

The motifs that I have been discussing, which resemble objects familiar to the observer, are called 'figurative'. Another group of motifs is 'non-figurative'. In the case of a non-figurative motif, the uninformed observer cannot arrive at any helpful associations for naming the figure. The solution to the problem of naming a non-figurative motif is to use terms from the European vocabulary of geometry and design which best describe the shape of the figure—e.g. circle, chevron, undulating line, sun disc, grid, etc. Names given to figurative and non-figurative motifs—e.g. 'kangaroo' and 'circle'—have the same status in both cases, that is, they have no interpretive value but are simply labels for recurrent arrangements of lines and shapes.

The list of names of motifs in use among a group of rock art commentators will represent an informal consensus, based on their common cultural experience. It could not even be claimed that 'kangaroos' are universally recognisable by 'European' observers. To an extent, therefore, the names of motifs are a sort of technical jargon peculiar to specialist groups of rock art fanciers. The distinction between figurative and non-figurative is based on the viewer's unassisted capacity to interpret.

The naming of motifs in publications introduces the possibility of variation between different writers. As long as explanations and illustrations are adequate there is no need to call for a standardised list of Australian motif-names.

*Size* (see Table 4)

As well as actually measuring the longest dimension of a figure, it may sometimes be useful in the case of a figurative motif to relate its size to the average size of the object on which the scheme is modelled. I admit that this process is both subjective and approximate. There are wide variations in

*Table 3*

**ROCK ART MOTIF**

*Figurative*

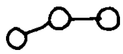
Examples of names of figurative motifs:

Man, woman, human (no sex indicated)
Kangaroo, dingo, flying fox, echidna, animal (quadruped of unidentifiable species)
Emu, scrub turkey, bird (unidentifiable species)
Sawfish, eel, dugong, fish (unidentifiable species)
Crocodile, turtle, lizard, snake
Yam, plant
Boomerang, spear, shield, axe, basket, canoe
Human footprint, hand
Kangaroo track, bird track, lizard track
. . . etc.

*Non-figurative*

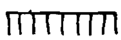
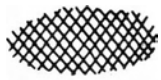
Examples of names of non-figurative motifs:

Circle, oval, rectangle, diamond

Linked circles 
Chain of circles 
Row of circles 
Connected circles 
Group of circles 
Bisected circle 
Quartered circle 
Spoked circle 
Concentric circle 
Spoked concentric circle 

Line: straight, curved, wavy, looped, sinuous, zig-zag
Parallel lines, radiating lines, intersecting lines, maze
Spiral, chevron, U, concentric U, cross

Common nouns used as names of non-figurative schema—no interpretation in favour of the referent is implied:

Rake 
Herringbone 
Star 
Sun disc 
Grid 
Ladder 
Amoeba 
. . . etc.

(From L. Maynard, Classification and terminology in Australian rock art. In: P. J. Ucko (ed.), *Form in Indigenous Art*. Canberra, Australian Institute of Aboriginal Studies, 1977, p. 395; by permission.)

*Table 4*
**ROCK ART SIZE**

*Absolute*
Measurement of longest dimension in metres and centimetres.

*Relative*
(Optional) Applies to figurative motifs only.

| *Size categories* | *Code* | *e.g. Human figure* |
|---|---|---|
| Larger than life size | LL | More than 180 cm |
| Life size | L | 120–180 cm |
| Half life size | ½L | 60–120 cm |
| Miniature | M | Less than 60 cm |

(From L. Maynard, Classification and terminology in Australian rock art. In: P. J. Ucko (ed.), *Form in Indigenous Art*. Canberra, Australian Institute of Aboriginal Studies, 1977, p. 398; by permission.)

scale in Australian figurative rock art from giant representations to tiny miniatures. It may be helpful to use these relative size categories for comparing and contrasting art in different areas, in which case their usefulness might outweigh the lack of accuracy in some instances.

*Character* (see Table 5)

If a group of artists, when making figurative representations of the same subject, all tend to distort its shape away from 'photographic reality' in the same way—the resulting figures will all appear somewhat homogeneous. They will constitute a subgroup within the motif. For example, a number of human figures with greatly elongated limbs and torsos would stand out from a group which displayed more or less normal body proportions. Similarly, a group of non-figurative motifs may have characteristics which distinguish it from another group—e.g. embellished versus simple.

Some figures, therefore, need something extra added to their identification by motif. It is first necessary to take a broad view of Australian rock art in order to describe norms from which some figures deviate. The general character of most Australian figurative art is crudely naturalistic, faithful to the general proportions of the subjects on which it is modelled but not very realistic nor stylised.

If a figure is not described in any special terms under the heading Character, this means that it does not vary in any appreciable way from the description given above. In order to have character, a figure must stand out in some way.

The list of suggested characteristics is not exhaustive or absolutely standardised. Nevertheless, if in a single piece of work, characters are described consistently, then, when compiling quantitative data one can count up the number of times that they occur and use the results in the same way as the other descriptive categories can be used—e.g. 10% of men are carrying objects in their hands; 63% of fish are X-ray, etc.

In Australia, many bodies of rock art consist of a large number of figures within a particular geographical location which consistently display a narrow range of traits.

Thus most rock carvings in the Sydney area are:

| | |
|---|---|
| Technique: | pecked (Table 1, Bii) |
| Form: | outlines (Table 2, 1c, 2c) |
| Motif: | figurative |
| Size: | size range: absolute = 30–900 cm relative = half life-size to larger than life |
| Character: | no character |

That is, we have an area in which most of the carvings can be described by five criteria selected from the terminology of Australian rock art. This means that we can refer to the 'Sydney rock carving style'.

*Table 5*
**ROCK ART CHARACTER**

*Examples of distinguishing characteristics*

*Shape*
Elongated, stick-figure, enlarged head, enlarged genitals, contorted posture, showing movement, 'flexible' limbs, profile depiction, realistic body contour, Wandjina, Mimi, Kurangara, X-ray, etc., elaborately decorated, very detailed, . . . etc.

*Association*
Wearing headdress, carrying object in hand, struck by weapon, striking other figure, copulating, . . . etc.

(From L. Maynard, Classification and terminology in Australian rock art. In: P. J. Ucko (ed.), *Form in Indigenous Art*. Canberra, Australian Institute of Aboriginal Studies, 1977, p. 398; by permission.)

What to do about the exceptions? The 25% of non-figurative figures conform to the other four criteria—they consist of pecked outlines ranging from 30 to 350 cm and they have no special character by comparison with others in Australia. These seem good grounds for the incorporation of these figures into the Sydney style. The very small number of figures which deviate in other ways do not display any consistent pattern of traits—therefore they do not form a second style in the area.

In the Cobar area (Mount Gundabooka, Wuttagoona, Iona, Mount Grenfell, etc.) most of the cave art is:

| | |
|---|---|
| Technique: | painted (Table 1, Ei) |
| Form: | solid figures (no infill) |
| Motif: | figurative |
| Size: | 10–30 cm, miniature |
| Character: | no character. |

These two examples (the Sydney rock carving style and the Cobar cave painting style) are very simple—five criteria are all that are needed to describe most of the figures.

The style of the ancient rock engravings in South and Central Australia is slightly more diverse:

| | |
|---|---|
| Technique: | pecked (Table 1, Bii) |
| Form: | bands and thick outlines and solid figures (Table 2, 1d, 1e) |
| Motif: | restricted range of motifs, mostly non-figurative plus kangaroo and bird tracks, but with the different motifs occurring in very consistent ratios |
| Size: | 15–60 cm, relative size not applicable |
| Character: | no character. |

Although the number of traits is a little larger and a quantitative concept has been

introduced to illuminate the motif situation, these carvings still constitute a 'style' under my definition of a large number of figures conforming to a small number of selected traits. This use of 'style' for a group of figures found at numerous sites within a defined area roughly corresponds to McCarthy's regional 'type', but my usage is indissolubly linked to my system of classification.

To conclude, the purpose of the proposed system of terminology is twofold. The first aim is to regulate the description of individual figures, both when they are described in full using the whole system, and when abbreviated descriptions are used which derive from the total system. The second aim is the identification of Australian rock art styles by observing 'clusters' of particular characteristics manifested in large groups of figures.

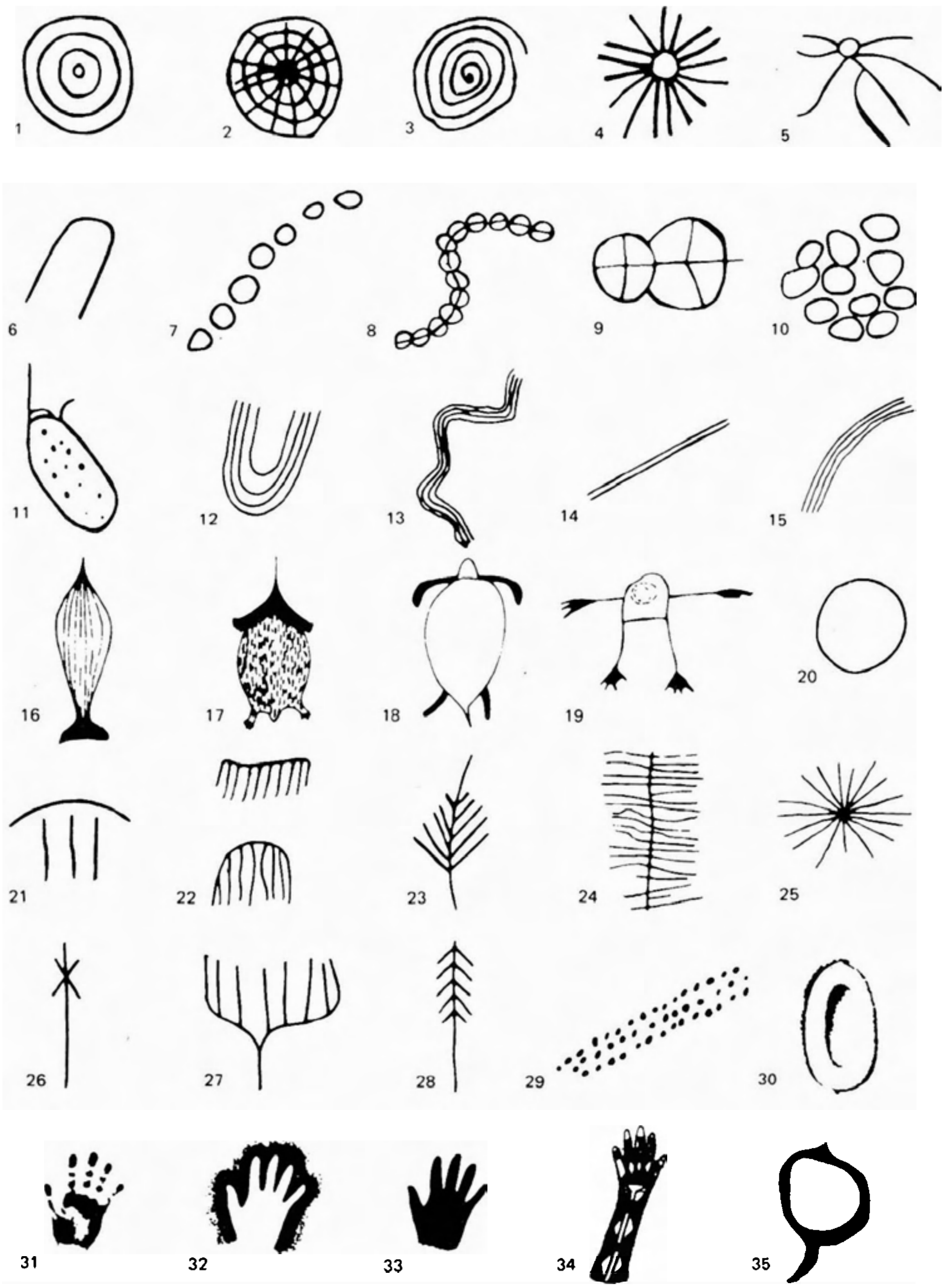



*Fig. 1*
*Composite of McCarthy's Figs 1 and 2 in Mulvaney (1968), summarised as a column diagram in Table 6.*

## Method 5. Knobs and blobs

This is one way of refining the objectivity of motif classification and description. It also allows the definition of measuring points (Fig. 2) (Clegg *et al.*, 1977; Clegg, 1978c).

In the knob-blob approach, each picture, figure or glyph is seen as and analysed into one blob which has attachments described as knobs. The blob is thought of as the larger and more central bit. Knobs come in two sorts—longs and rounds (a distinction which may be made by measurement). Sometimes the knobs have on their backs smaller knobs—and one could continue in this way for as many knob-upon-knob generations as desired. But at present we restrict ourselves to the first generation of knobs. A glyph is described and classed by enumerating the long and round knobs, usually in order, and by convention starting at a round which is situated at or near the end of the blob, proceeding thence clockwise round the whole glyph.

The stages through which any recording must go are:

(1) Obtain a permit.
(2) Find the object to be recorded.
(3) See it.
(4) Record it (repeat 3 and 4).
(5) Process the recording till it is in a publishable state.
(6) Make the recording available.

There are many ways of making prehistoric art more easily visible than it may appear at first, and some of these will be described in their turn. But there is only one way of seeing the pictures, and that is to look at them. One way of looking at pictures is to fill in a questionnaire of the sort which arises from methods 2, 3, 4 and 5. The other way of looking at pictures is to draw them. It also helps with disentangling the various pictures on the rock. Each has to be untangled, not only from the other drawings but from the bedding planes which decorate the surface, and from cracks, and differences in colour which result from fresh erosion or dusty deposition or the marks left by fauna—wasp nests, termite runs, birds' nests—and so on.

## Method 6. Sketching

*Ingredients*

Permit
Paper
Coloured pens or pencils
Patience

*Table 6*

**COLUMN DIAGRAM DESCRIBING FIG. 1**

(Letters and numbers are taken from Tables 1 and 2. R = red, W = white, Y = yellow, B = black, M = multiples, F = figurative, NF = non figurative)

| *Figure* | *Technique* | | | | | | | | | | *Form* | | | | | | | | | | | | | | | | | | | | | | *Motif* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Ai* | *Aii* | *Aiii* | *Bi* | *Bii* | *C* | *Di* | *Dii* | *Ei* | *Eii* | *1a* | *1b* | *1c* | *1d* | *1e* | *2a* | *2b* | *2c* | *3a* | *3b* | *4a* | *i* | *ii* | *4b* | *4c* | *4d* | *i* | *ii* | *iii* | *iv* | *4e* | *4f* | *M* | |
| 1 | X | | | | | | | | | | | | X | | | | | X | | X | | | | | X | | | | X | | | | | NF concentric circle |
| 2 | | | | | | | | | X | | | | R | | | | | X | | X | | | | | X | | | | R | R | Y | | | NF spoked concentric circle |
| 3 | | | | | | | | | | X | | | B | | | | X | | X | | | | | | | | | | | | | | | NF spiral |
| 4 | | | | X | | | | | | | | | | X | | | | X | X | | | | | | | | | | | | | | | NF sun disc |
| –& | | | | X | | | | | | | | | | X | | X | | | | | | | | | | | | | | | | | | |
| 5 | | X | | | | | | | | | | | X | | | | | X | X | | | | | | | | | | | | | | | NF circle and intersecting lines |
| –& | | X | | | | | | | | | | | X | | | X | | | | | | | | | | | | | | | | | | |
| 6 | X | | | | | | | | | | | | X | | | X | | | | | | | | | | | | | | | | | | NF U |
| 7 | | | | | X | | | | | | | | X | | | | | X | X | | | | | | | | | | | | | | 7 | NF row of circles |
| 8 | | | | | X | | | | | | | | X | | | | | X | | X | | | | | X | | X | | | | | | 13 | NF chain of bisected circles |
| 9 | | | | | | | | | X | | | | | W | | | | X | | X | | | | | X | | W | W | | | R | | 2 | NF linked quartered circles |
| 10 | | | | | | X | | | | | | | X | | | | | X | X | | | | | | | | | | | | | | | NF group of circles |
| 11 | | | | | | | | | X | | | | Y | | | | | X | | X | X | Y | | | | | | | | | R | | | NF oval and intersecting lines |
| –& | | | | | | | | | X | | | | Y | | | X | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | X | | | W | | | X | | | | | | | | | | | | | | | | | 4 | NF concentric U |
| 13 | | | | | X | | | | | | | | X | | | X | | | | | | | | | | | | | | | | | 4 | NF parallel undulating lines |
| 14 | X | | | | | | | | | | | | X | | | X | | | | | | | | | | | | | | | | | 2 | NF parallel straight lines |
| 15 | X | | | | | | | | | | | | X | | | X | | | | | | | | | | | | | | | | | 4 | NF parallel curved lines |
| 16 | | | | | | | | | X | | | | R | | | | | X | | X | | | | | X | | R | | | | Y | | | F fish |
| –& | | | | | | | | | X | | | | | | R | | | | | | | | | | | | | | | | | | | |
| 17 | | | | | | | | | X | | | | W | | | | | X | | X | X | | W | | | | | | | | Y | | | F echidna |
| –& | | | | | | | | | X | | | | | | W | | | | | | | | | | | | | | | | | | | |
| 18 | | X | | | | | | | | | | | X | | | | | X | X | | | | | | | | | | | | | | | F turtle |
| –& | | | X | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | |
| 19 | | | | | X | | | | | | | | X | | | | | X | | X | | | | | X | | | | | X | | | | F human |
| –& | | | | | X | | | | | | | | X | | | X | | | | | | | | | | | | | | | | | | |
| –& | | | | | X | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | X | | | B | | | | | X | | X | | | | | | | | | | | W | | | NF circle |
| 21 | | X | | | | | | | | | | | X | | | X | | | | | | | | | | | | | | | | | 4 | NF non-intersecting lines |
| 22 | | | | | | X | | | | | | | X | | | | X | | X | | | | | | | | | | | | | | | NF rake |
| 23 | | | | X | | | | | | | | | X | | | X | | | | | | | | | | | | | | | | | | NF herringbone |
| 24 | X | | | | | | | | | | | | X | | | X | | | | | | | | | | | | | | | | | | NF ladder |
| 25 | | | | | | | | | X | | | | Y | | | X | | | | | | | | | | | | | | | | | | NF star |
| 26 | | | | | | | | | | X | | | B | | | X | | | | | | | | | | | | | | | | | | NF intersecting straight lines |
| 27 | | | | | X | | | | | | | | X | | | | X | | X | | | | | | | | | | | | | | | NF rake |
| 28 | | | | | | | | | X | | | | R | | | X | | | | | | | | | | | | | | | | | | NF herringbone |
| 29 | | | | | X | | | | | | | X | | | | X | | | | | | | | | | | | | | | | | | NF parallel straight lines |
| 30 | | X | | | | | | | | | | | X | | | | | X → | | | | | | | | | | | | | | | | NF cup and ring |
| –& | | | X | | | | | | | | | | | | | | | | | → X | | | | | | | | | | | | X | | |
| 31 | | | | | | | | X | | | | | | | Y | | | | | | | | | | | | | | | | | | | F hand imprint |
| 32 | | | | | | | X | | | | | | | | W | | | | | | | | | | | | | | | | | | | F hand stencil |
| 33 | | | | | | | | | X | | | | | | R | | | | | | | | | | | | | | | | | | | F hand |
| 34 | | | | | | | X | | | | | | | | W | | | | | | | | | | | | | | | | | | | F decorated hand stencil |
| –& | | | | | | | | | X | | | | R | | | | | X | | X | | | | | X | | | | | R | | R.Y | | |
| 35 | | | | X | | | | | | | | | | X | | | | X | X | | | | | | | | | | | | | | | NF circle and intersecting line |
| –& | | | | X | | | | | | | | | | X | | X | | | | | | | | | | | | | | | | | | |

(From L. Maynard, Classification and terminology in Australian rock art. In: P. J. Ucko (ed.), *Form in Indigenous Art*. Canberra, Australian Institute of Aboriginal Studies, 1977, p. 400; by permission.)

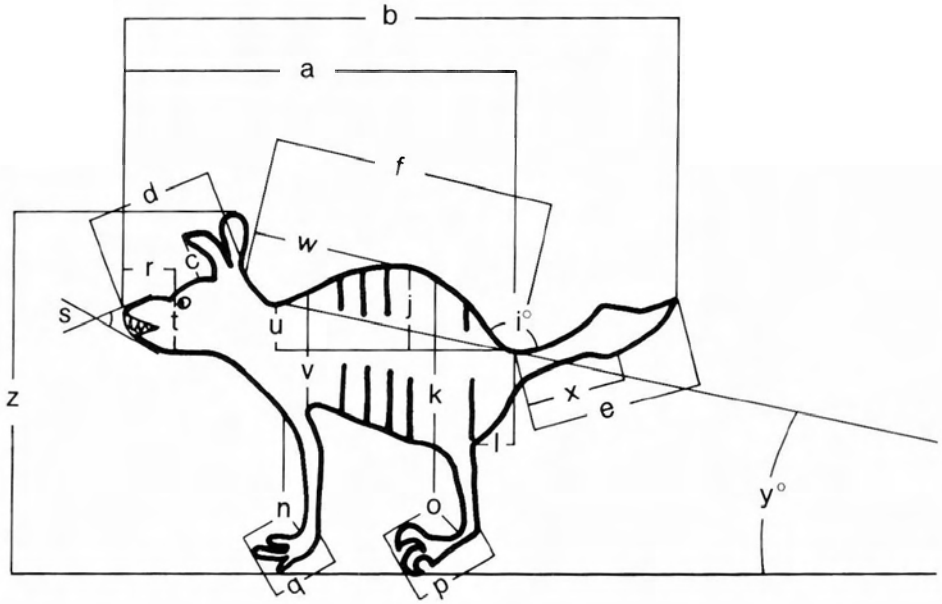



*Fig. 2*
*Measuring points.*

*Method*

The process is to sketch the figures one by one, in a colour which, if not correct, at least enables the colour of one drawing to be distinguished from others. The sketch provides an expression of what the recorder sees and is analogous to an hypothesis. It can be checked by several methods. The recorder moves closer to the rock, or puts on coloured glasses, or illuminates the rock by some artificial method. The sketch may stand up to this test, or may be revised. This process continues till the whole surface has been sketched and it can be compared with the whole picture. At this stage one can ask which of the marks on the rock have not been explained or accounted for as parts of one of the drawn figures. The unexplained marks may make a figure of their own, or be subsumed as a previously unrecognised portion of a known figure. They may be recognised as part of the rock, natural and irrelevant additions by other fauna, or even portions of some faded and indecipherable figure.

Once the recorder is satisfied with the sketch it may be compared with the one produced by a companion recorder, and discrepancies resolved or agreed. The whole sketching procedure is essential; through it the recorders are enabled to *see* the prehistoric picture. There are many controls which are incorporated in the hope of achieving a reliable result, but the basic technique is that of projecting an interpretation onto the data; the interpretation may be rejected. Such a rejection can be accepted as rather more meaningful than an acceptance, for it is all too easy to accept one's projections as the real external object onto which they are projected. This is why we try to project alternate hypotheses, and why it is best to use independent observers.

The best confirmation that can occur is the discovery in a nearby site of another, clearer example of a figure which has been sketched. After the sketching process, fuller recording by photography, tracing, etc., may proceed—one knows what to point the camera at. During the processes of tracing

*Fig. 3*
*Rock drawings at Woronora, NSW. Study this picture carefully and see what you can make out of it before you read on.*



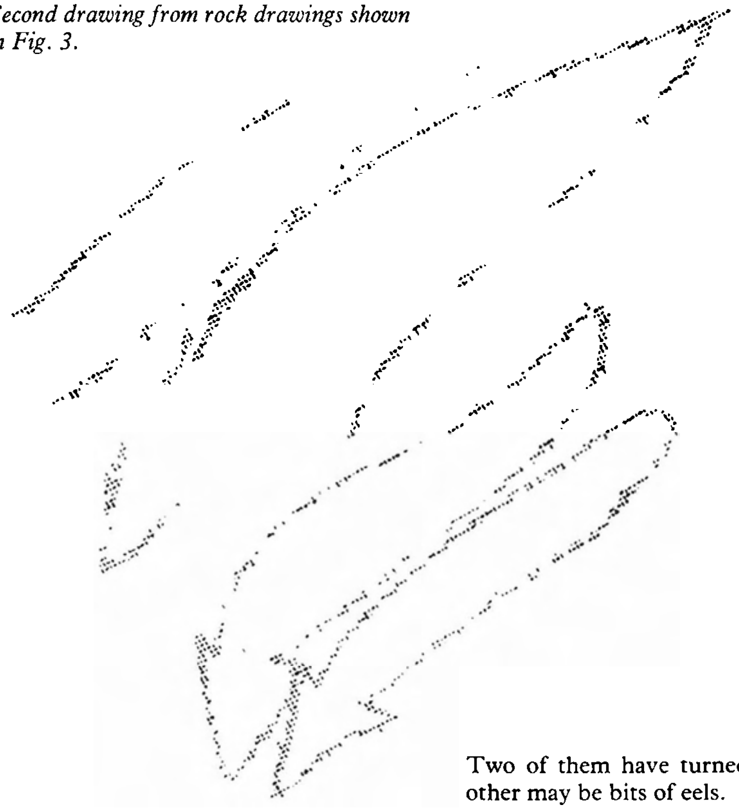
and photography it is quite common for a figure to present itself for the first time, or in a (literal or figurative) new light. The best way I know of to look at art is to make sketches of it. The sketches are your own, they are helping you to look and to see; they are not for showing round to other people. So it does not matter if they do not come out quite right.

I can try to explain with an example. It is not easy to do this without a real example before us; the following exercise works quite well if one has a *coloured* picture or a slide projected. Since we can not use colour here, I shall have to try and tell you how to do it in grey-and-grey. I have found that people really need to do the exercise in practise before they understand the points I am making; that you need to draw things in order to see them properly, and that the more you look, the more you see. If you can, obtain a coloured photograph or slide of some prehistoric picture, and actually try for yourself your own example of the following. Figure 3 (for which you can substitute a coloured picture) is of a bit of rock at a site called Woronora, south of Sydney. The area in the photo is about 2 metres by 1 metre, so the whole thing is pretty small by comparison with most of the prehistoric art in the Sydney area. On the rock we can see at first a confusing mass of lines and spots. Let us take each line in turn and sketch it. There is one—look, it has turned into a kangaroo. It has two black ears. In practice, coloured pencils are used to make the drawings. I use a green pencil for white lines, a black pencil for black charcoal, and a red pencil for red lines. In grey-on-grey different colours are useful for the different thicknesses and textures of lines. Here is our big kangaroo with black ears (Fig. 4). There are two small animals which are clear because they are small. There are some long diagonal lines near the kangaroo; let us find them and see what they make. If they do not seem to make anything perhaps they will in the end.

*Fig. 4*
*First drawing from rock drawings shown in Fig. 3.*



*Fig. 5*
*Second drawing from rock drawings shown in Fig. 3.*



Two of them have turned into eels. The other may be bits of eels.

*Fig. 6*



It is time to sort out some natural lines. I've only put in a few bedding planes. There is something else there as well—and what about the black 'roo's hind leg? Is it there at all, or muddled with the eels? It is getting a bit difficult, so we will do a few easy bits.

*Fig. 7*



Some of these Vs are old friends: they make ears and legs; do the others?

Is that a back or a neck or both?



*Fig. 8*

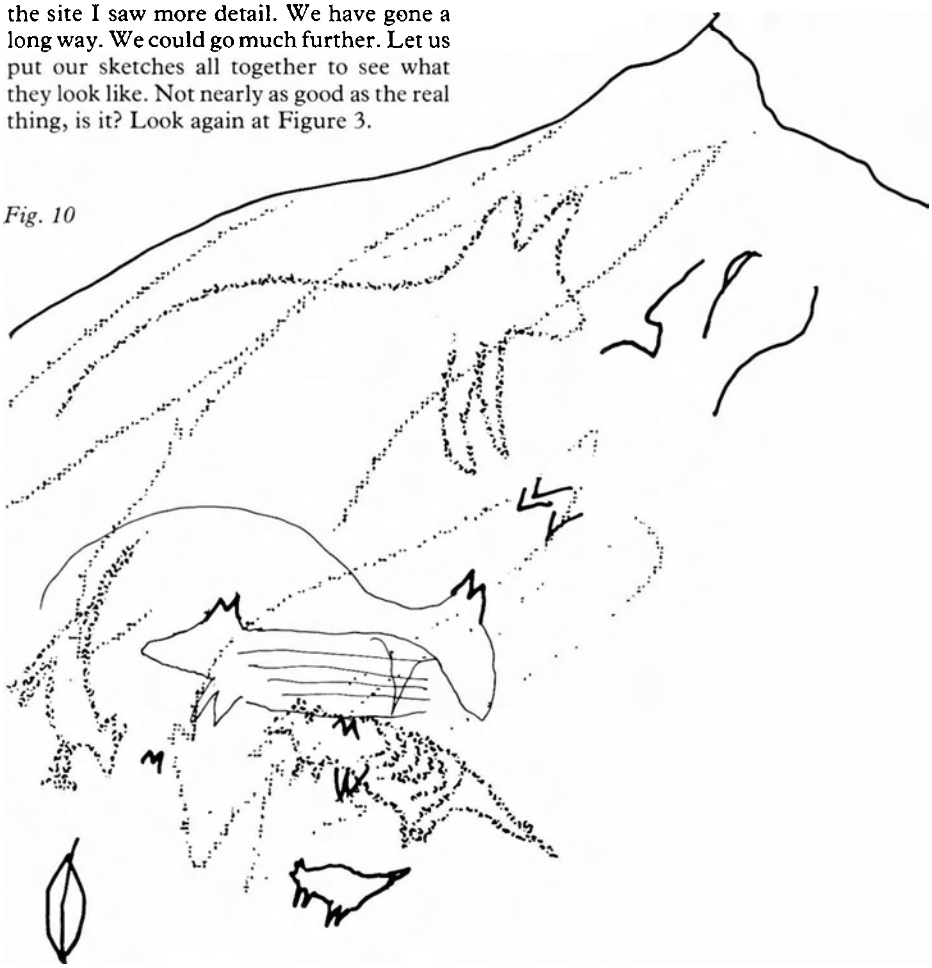
Aha! there's its leg—very faint.



*Fig. 9*

Well, by now it looks as though there is something in this game? A bit more than comes to eye at first. There is a lot left that I cannot see properly yet. Last time I visited the site I saw more detail. We have gone a long way. We could go much further. Let us put our sketches all together to see what they look like. Not nearly as good as the real thing, is it? Look again at Figure 3.

*Fig. 10*



Lots of hard work like that does let us get something out of the picture, but I am always surprised to find how easy it is to see the figures once you know where they are.

### Method 7. Miscellaneous methods for making drawings, paintings and stencils more visible

Seeing paintings and drawings can be made difficult by the complexity of the art, by poor lighting, by natural or non-humanly-made markings, by later human vandalism, or above all by the faded nature of some of the marks which leaves them difficult to distinguish from their background (Figs 11 and 12). Seeing faint drawings can also depend very much on the awareness of the individual. You cannot see it till you know it is there; once you know it is there, you can see it—even if you are wrong, and it's not really there, which could lead to mistakes.

Once one is aware of the danger, it is half conquered, but there are various devices which may improve the objectivity.

(a) *Explicate the first sight.*
At first sight of a site make very rough sketches of everything that can be seen on the wall. These can be used later to make sure you have not forgotten anything.

(b) *Use varied light.*
Look at the site from various angles. Go up one end, then the other. Lie on the floor to check the ceiling. Repeat this through the day, as the natural light changes with the moving sun.

Vary the light: put a reflector outside (a sheet of white paper does very well in the sun) to shed more light on the subject; use artificial lights if available. Look at the art through various filters: polaroid sunglasses, coloured celluloid—all act as filters bringing up some colours, hiding others (see Edwards, 1968: 85, on filters). This process of seeing continues through the recording. Atmospheric conditions of humidity and temperature, to say nothing of incident light, alter the appearance of pigment on rock surfaces. It pays to visit the site at different seasons and times of day.

### Method 8. Miscellaneous methods for making engravings, poundings and peckings more visible

There are various methods for making rock engravings more visible which depend on using oblique light. Natural oblique light—dawn or dusk—is very good but the best of these methods is J. C. Lough's (1973) night recording technique, which is best learnt from Mr Lough. I understand that acetylene lamps are used to illumine the engraving, the lamps being held very close to the surface of the rock, so that the light is cast almost parallel to the surface. A variation of this is the use of hand mirrors in daylight. Shadow is cast on the engraving by interposing a person, hat or umbrella between the engraving and the sun; the mirror is used to cast light across the groove under investigation (Fig. 13). Since the light cast illuminates only a small part at a time it may be necessary to create a visible memory of each groove: this is best done by putting a chain in the groove as it is found—the use of sand or chalk is frowned on. Engravings which are obscure to vision may be clearer to touch. Fingers run across the line of the engraving, as well as along it, usually clarify the position.

Human awareness of depth is caused by several cues. One is shadow, another is stereoscopic, binocular vision. Human eyes are about 55–60 mm apart. When an object is seen by both eyes the resultant image is



*Fig. 11*
*Drawing on rock and marks from wasps' nests.*

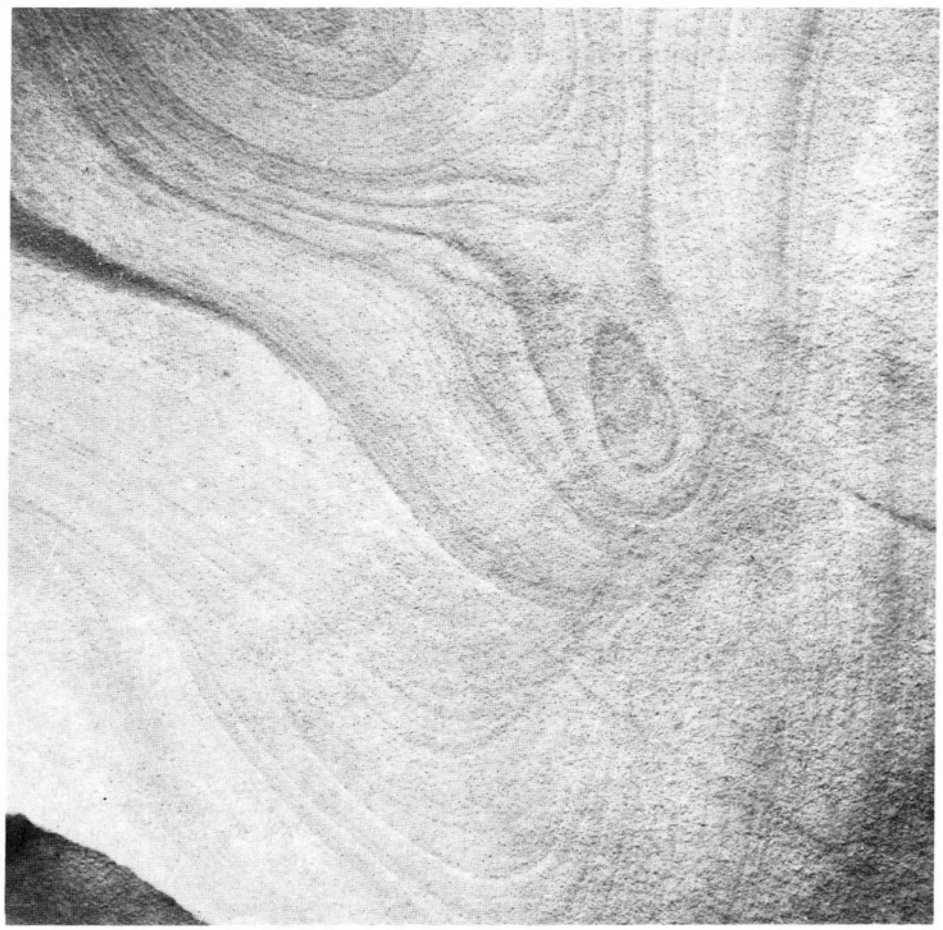
Should marks made by nature be recorded? Should later graffiti be recorded? Here are two guiding principles:

(a) One can always remove redundant information but never replace it, if it is unrecorded, without a revisit to the site.

(b) If a natural mark is recorded the same way as a man-made one, it will be mistaken for it and the recording will be erroneous. Any natural marks which might be relevant to the art presumably should be recorded; any graffiti which *might* be of prehistoric origin *must* be recorded. It is useful to know the bounds of the paintable surface.

So the answers seem to be to record everything, but to make sure the recording enables discrimination between natural and man-made.

*Fig. 12*
*Drawing and rock bedding.*



formed from two places, 55 mm apart. If the vantage points were further apart the apparent depth of the object would be increased. There is a device invented by Frank Dickson of Sydney, and irreverently named 'the Dickson eye-stretcher', which consists in principle of a pair of periscopes whereby the observer's eyes look out from stations 500 mm or so apart, thus enhancing the apparent depth of grooves.

Some engravings are obscured by lichen or other vegetation or graffiti. There are methods of removing these but the methods are likely to cause more damage than the good they do; before any sort of cleaning, permission must be obtained from the relevant State authority, who will usually have experience and expertise available.

## FURTHER DISCUSSION OF RECORDING PROBLEMS

We are now in a position to record whereabouts the prehistoric art is, and we have discussed various means of looking at and seeing the art. A little further discussion is necessary before launching into the more complex methods.

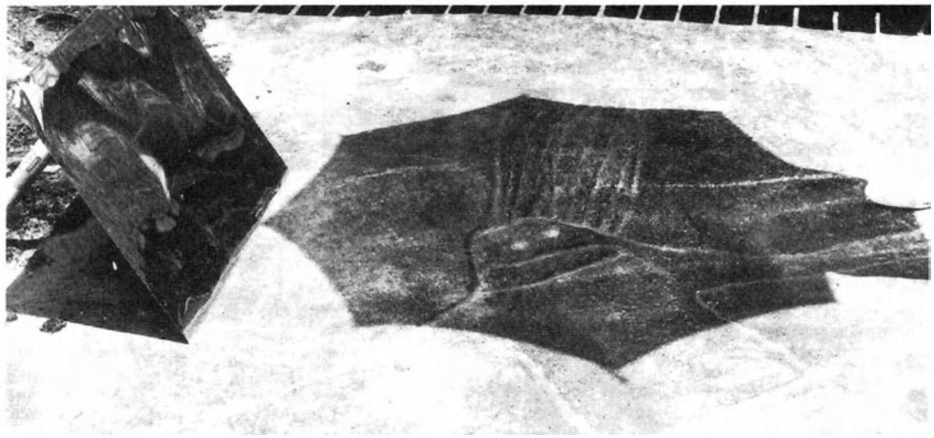


*Fig. 13*
*Engravings shaded by an umbrella and lit by oblique light from a mirror.*

## Natural marks like engravings

Most stone contains cracks of various sorts. Where these are on the surface, they get widened by erosion, and produce a groove which is V-shaped in cross-section, deepening towards the centre. An engraved groove is U-shaped. Running water erodes marks also, and an intermittent stream bed is easy to distinguish from an engraving. Colour differences, produced by sticks lying on the rock or the activities of insects, may be distinguished from engravings because they are superficial and do not coincide with grooves. Rubbing grooves can be made by branches and wind. So far it is not possible to distinguish a groove made by wind pushing wood from that made by man pushing wood (or however they made engravings).

## Natural marks like drawings

Bedding planes in the rock often (especially in sandstone) show different colours. They are usually parallel to more bedding planes and bear some relation to the detailed shape of the rock. Stand back and look at the rock as a whole and they can usually be spotted. Other odd coloured inclusions in the rock can be recognised if they have been the subject of differential erosion, so they feel different, or stick in or out.

Some insects make nests, tracks, etc. Some drawings are drawings of marks left by insects. Caution all round.

Ledges in rock shelters collect dust, which may obscure a drawing or be mistaken for it. Water washes drawings about.

When in doubt, record everything, and photograph it under various conditions.

## Recording procedures

In the recording of engravings, there is room for discussion about how wide to make the line. Some recorders use only the line of the deepest part of the engraving; others insist that the engraving as originally made would have a line of a certain width which should be recorded in detail, i.e., the recorded points should be the edges of the engraved lines. This certainly produces a very pretty effect which can be no further from the original than any other. Precisely how accurate it is must of course depend on the precise type of erosion that has taken place. Ideally, I suppose, the recording would show boundaries and centre of engraved line, dot, or area.

Recording may involve careful copying, mark-for-mark. In this process the copiers are so close to the work in progress that they may be unaware of the whole figure. The vision of the wood, which was built up sketching, is checked in the close examination of the trees. Copying the trees instead of the wood leads to variation; *mistakes* on the one hand, and *corrections* on the other. A variation is discovered, and categorised, by comparison with sketches and discussion with colleagues.

A twentieth century researcher can make observations about marks on surfaces. The observations can be objective enough to support work which is to be based on them. But it is much more difficult to make observations about what may be physical facts identical with the marks on surfaces, for instance drawings of kangaroos, i.e., motifs and representations. The apparently simple statement 'that is a drawing of a kangaroo' when analysed is very complex. The drawings of things, as the researcher sees them, are the value-laden projections of his/her own vision. This process is named 'interpretation', and is to be avoided. It is necessary to develop methods which *reduce* 'interpretation' (though it can never be eliminated) and *increase* objectivity, reliability and repeatability. It is proposed to maximise objectivity by classifying motifs into groups which differ from each other in ways which are assessed by comparison with other drawings, paintings or engravings. If the motif-classes turn out to look like real objects, then the name of the object may be used as a label. This labelling is done without prejudice to the likelihood that the pictures represent something completely different, or nothing.

It is most curious that the interdependence of recording and study is not completely accepted in Australia; it is common to encounter statements to the effect that first priority must go to recording the art as it is being destroyed fairly quickly; the study of it may be left until later. This would be fine if some means of producing an adequate record of any site had been devised.

Such an adequate recording would have an almost infinite amount of information in it, much of which would be useless to any one student. It would be useless for one of two reasons. First, the information would be *irrelevant* to the particular study—the details of the mineral structure of the rock might be important to a physical geographer studying erosion but he or she would find the meaning of the art irrelevant to such studies. An art historian would be interested in a little information about the 'canvas' on which the art is but would find the microstructure of the minerals

irrelevant. The second reason for uselessness is not that the information is irrelevant, but that the student is not skilled enough to extract relevant meaning from the information available. No one might have thought of a way of using that particular information. If there is no way of using the information it will be likely to be erroneously classified as irrelevant. As the techniques of archaeology improve, archaeologists find a use for more and more information. A recording method which was adequate a few years ago, because it recorded all the information which was then used or usable, is now inadequate. It cannot answer the questions which a modern archaeologist asks.

A recording is *complete* if it can provide information about (answers to) all the questions which the archaeologist is capable of using (asking). A recording is *accurate* if all those answers are the same, whether derived from the recording or the original. The idea of (absolute) adequacy must be reduced to the usable criteria of *completeness* and *accuracy*. This reduction is achieved by limiting the idea of absolute adequacy to relative adequacy. A recording may be said to be *adequate* if it is capable of answering all the questions asked of it by the researchers for their own purposes. If it were to contain all the information any researcher is capable of using, then an *adequate* recording would be one which contained as much information as did the object being recorded. Adequacy in this sense is as difficult to achieve as absolute objectivity, and as useless a concept. The more useful measure is one of degree; a more adequate recording contains more information—more relevant information—than a less adequate one. It could, for instance, be argued that the *number* of hand stencils is more important than the precise delineation of each one, whereas the precise delineating of a figure may be more worthwhile than spending an equal amount of effort recording two similar figures less well.

The word *important* draws attention to a consideration which must have been obvious since the word *adequate* was first read: important or adequate to whom—for what purpose? All observation proceeds by asking questions. However idealistic one's aims are for adequacy, it is unlikely that one will manage to record very much more than one was aware of a use for, that one was able to ask questions about. If one is problem-oriented one could visit a site and record only those bits of information known, or considered, to be relevant to the solution of the problem. Such a course would be in the best interests of the worker, and presumably would represent the most economic use of effort and any contribution made by sponsors. Such a course has a grave limitation for the researcher: there is no leeway. Should there be a lack of omniscience at the planning stage, then the researcher might not include every relevant question from the beginning, for the excellent reason that the question was not available until she or he was in the field, or for less excellent reasons, e.g., she or he forgot or failed to think of an obvious question. Then the researcher must either retrace steps to make the extra observations, or achieve much less for the effort than she or he might otherwise manage.

Recording methods may be evaluated for their *relevance, completeness* and *accuracy*. *Relevance* depends on whether the task undertaken, of which the recording process is a part, can use the recording. The prime factor in *accuracy* is directness, or immediacy; the fewer the stages between original and completed recording, the less chance for error or lack of skill to wreak their respective havoc. *Completeness*, on the other hand, depends on how well the recorder is acquainted with the site; one needs to know there is something there before one points a camera at the spot, let alone chooses the correct filter, exposure, light source, film or day.

Small-scale recording, whether using a grid or not, is less direct than tracing, so liable to more error; and it is more difficult to record mark by mark instead of motif by motif.

Photography only records what is really there—but it does not necessarily record all that is there—one may need special filters to pick up some marks; some things show up well in bright light, others in diffused, dull light. From what is recorded, the observer selects, whether consciously or unconsciously.

In fact, the sort of selection and evaluation which go with phenomenological seeing is essential before objective-oriented observation can be attempted. One has to know where to point the camera.

Tracing is probably the most generally useful method of recording prehistoric art. But the tracing could miss out marks which had not been looked for, or seen as important, or had been merely forgotten; it could not be minutely detailed enough to balance sizes or colour hue or colour saturation of marks perfectly. Tracings are checked by comparing the picture on the polythene with the picture on the wall, and with the idea of the picture on the wall as produced by two or more other people. This cannot be a check on whether important areas of emphases have been inadequately rendered. So the phenomenological experience is used to check the accuracy. Two ways of looking (close-up and distant) are used. This is possible because the tracing is direct and life-size. The tracer is physically close to the drawing while recording it.

The tracings are made to fit as closely as possible to the surface of the picture. The surface is seldom flat, and there is no reason to expect the surface to be *conformable*—one of those surfaces, like a cylinder or cone, but not a sphere, which can be transferred to a flat surface without distortion. The problem is familiar from map projections (Coggins & Hefford, 1957). Unavoidable distortions arise from pictures being on unconformable surfaces, but it is possible to transform the information of one projection onto any other projection, if the shape of the surface is known, as well as the rules which went into the production of the projection. In order to provide this information, it is necessary to map the picture support in detail.

With tracing, mapping, stereophotography in colour or monochrome, among many other methods, there are techniques available for the researcher to record any information deemed necessary. Australian prehistoric art has great potential to elucidate Australian prehistory. There are difficulties attendant upon the exploitation of the art for this purpose. Some difficulties are general to archaeology, others specific to art. All archaeology uses only *samples* of data. Only a small proportion of the artefacts made survives. Of those which survive few come to the attention of archaeologists, and even fewer are documented in a usable form.

The problems specific to art are those of preservation and seeing. Normal erosion obscures some parts of pictures, and deposition hides others. However completely the picture survives, a recorder may fail to recognise the whole. It is possible to make very detailed and accurate measurements which are based on less accurate recordings of the artefact. Great accuracy of measurement may be misleading, and suggest that the information is of a greater reliability than it is. We need a processing method which will get its reliability from a large number of observations, each of which is fairly gross. The large number means that conclusions, if any, will be backed up by many votes; a single misplaced vote will

not make much difference. The grossness of the observations to be used should allow any variations which result from poor recording, camera tilt, and so on to be so small that they do not affect the result.

## MORE COMPLEX METHODS

### Method 9. Tracing large painted or drawn pictures

*Prerequisites*

Methods 1 and 6
A permit from the State authorities

*Ingredients*

1 roll of transparent polythene sheet, 2 m wide, and as thin as possible

3 rolls of masking tape of good quality

2 rolls of Bostik Blu-Tack

2 pairs of scissors

Plumb-bob, compass

2 sets felt-tipped pens, of various colours and sizes (Make sure these write on Polythene—some do not. It depends on whether they have ink which is alcohol-based or water-based.)

Colour chart

Sharp knife to sharpen the felt-tip pens.

*Method*

It is standard to use sheets of 2 m by 2 m but smaller ones may be used if necessary.

(a) Attach sheet closely to the rock surface. Use masking tape or Blu-Tack, of course avoiding the actual painted surface. The plastic can be cut to fit any surface, but this fitting will distort apparent direction. If there is too much plastic, cut it away and discard it.

(b) Each sheet must have the following:
200 mm clear all round;
clear indication of DOWN—the equivalent of a north arrow;
enough overlap to the next sheet for reconstruction;
written words.

(c) Trace the pictures onto the polythene; use colours conventionally, making sure that there is a key available which can translate the ink colours to the 'real' ones.

(d) Take down the first sheet. Remove adhesive, store for transport to laboratory.

(e) Repeat till satisfactorily complete.

(f) Monitor process with photography.

### Method 10. Tracing small painted or drawn pictures

As method 9 but use acetate transparent plastic, which comes in rolls 255 mm wide. Acetate is a bit more transparent than polythene, and less subject to stretching. It needs water-based, not alcohol-based, inks.

This medium is also convenient for small, difficult portions of large sites which are traced on polythene.

### Method 11. Tracing with paints

As methods 9 and 10. Where it is considered crucial to get the colours right on the tracing, instead of using conventions, correct colours may be mixed from acrylic paints. I have found it both adequate and convenient to use small tins of British Paints Nu-Plastic: black, white, fanfare red and banana yellow, if mixed in suitable proportions, can match the various ochre colours. Take a green or blue as well, for the orientation and labelling data.

Tracings of themselves are not adequate. Unless the decorated surface is flat the flat tracing cannot represent it correctly, so it is necessary to have a record of the shape of the surface, into which the tracing can be keyed.

The tracings are usually awkwardly large, and should be reduced by photography.

### Method 12. Recording the shape of the decorated surface

As in map-making, the best way of expressing relief is through contours, so contoured maps of decorated surfaces are most useful. Often it is convenient to make the map in a vertical plane, so that it is technically a contoured elevation, rather than a contoured map. In both cases the contours should be based on spots at $\frac{1}{2}$-metre intervals, contour interval at most $\frac{1}{2}$ m. The making of such maps is best thought of as a job of surveying and is probably done most cheaply by photogrammetry (see Chapters 4 and 5).

### Method 13. Stereophotographs of site

*Prerequisites*

Permit
Methods 1 and 6

*Ingredients*

Camera
Film (preferably colour)

*Method*

(a) Stand at a suitable distance from the subject so that you are photographing what you intend to take. Have your feet $\frac{1}{2}$ m apart.

(b) Focus, calculate exposure, etc.

(c) Note some feature in the centre of the field of view.

(d) Shift your weight to the left foot—hence moving the camera to the left. Keep it pointing at the central feature (Fig. 14).

(e) Take the photograph.

(f) Shift weight to right foot, camera to right, still centring the view on the same feature. Take the second photograph.

(g) Have prints made from the film, and mount them for stereo-viewing, about 50 mm between matching points.

This method is not photogrammetry or surveying; reliable measurements of depth cannot be made, but it does produce a three-dimensional image very cheaply.

*Fig. 14*
*The author taking a stereophotograph. Photograph by David Smith.*



### Method 14. Stereophotographs of site details (Fig. 15)

Ingredients and method as for Method 13.

This method is most useful where a three-dimensional feature of the rock is relevant to the art, where natural features are incorporated into the picture or where some detail of superpositioning needs to be documented. Brush marks may be recorded in close-up stereophotography, or the individual character of engraving techniques, erosion patterns, and so on.

### Method 15. Tracings of engravings

*Prerequisites*

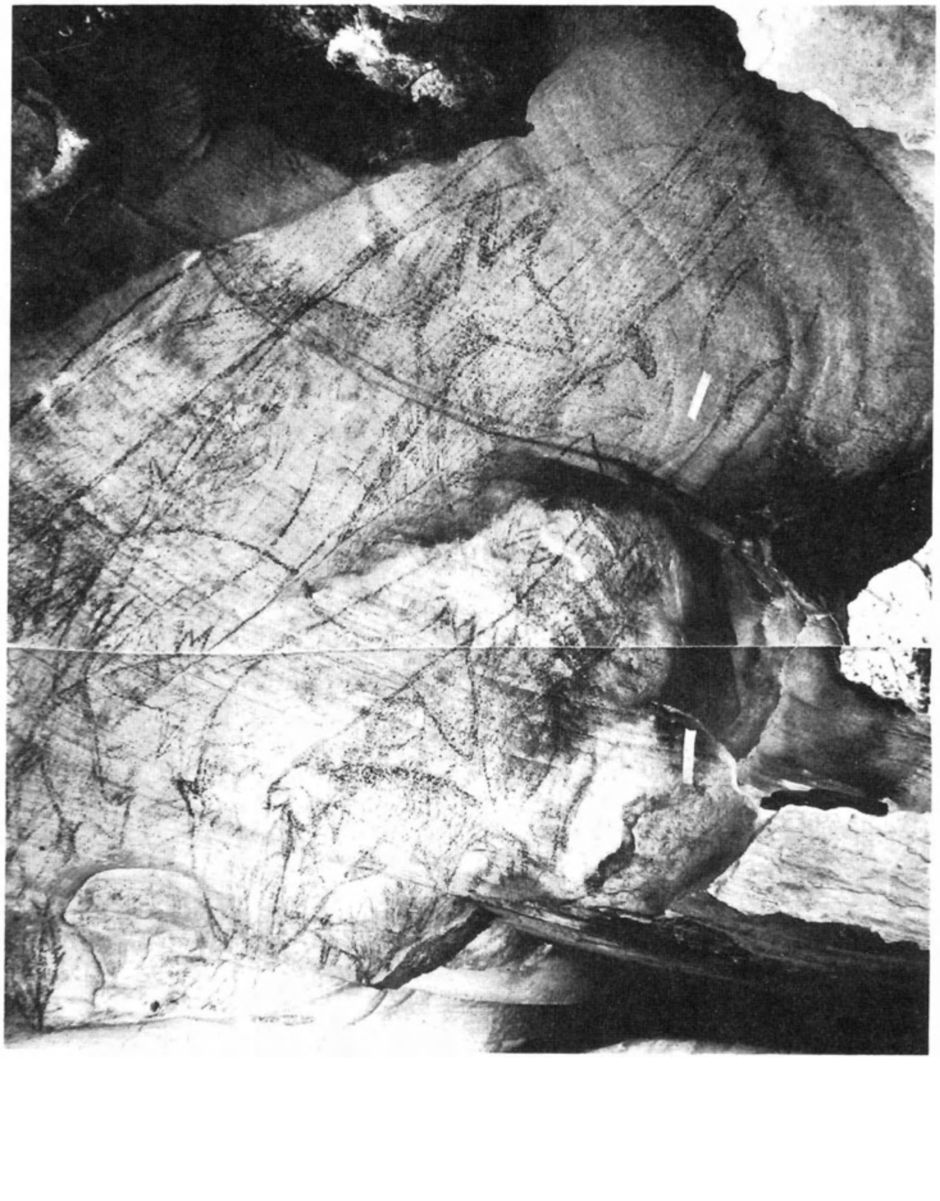
A permit from the state authority
Methods 1 and 6

This method is applicable to large engravings where there is no colour difference between groove and natural rock and where permission may be obtained to use chalk. The particular difficulty is that the engravings are so large that it is only possible to trace (or indeed see) portions at any one time. The tracing as such is precisely the same as explained in method 9, which traces using felt-tipped pens, onto polythene sheeting standard 2 m by 2 m.

*Ingredients for tracing*

Polythene sheeting, 2 m wide, 1 roll
Masking tape, weights, etc.
Compass, tapemeasure
Felt-tipped pens in three separate colours for engraving, natural features, north points and other writing

*Fig. 15*
*Stereophotographs of rock engraving. The scale is a 4 cm cube.*



The tracing is of chalk marks made carefully on the rock, where the engraving can be sensed. There are three methods for sensing faint engravings and chalking them in. The chalking itself is done *lightly* and later *washed off*.

*Ingredients for chalking*

Permit from state authority
Supply of coloured chalk
Water, buckets
Non-ionising detergent

*Ingredients for seeing engravings*

(a) 'Eye-stretcher'
Method: Look at rock through Dickson eye-stretcher which enhances the depth of each depression. Lightly chalk the bounds of each depression. Use one colour for definitely artificial, another for definitely natural, a third for 'don't know'.

(b) Mirror
Umbrella
Sunlight
Method: Arrange the mirror and umbrella so that sunlight is reflected at a very low angle over an area (see Fig. 13) of groove which is sheltered from direct sunlight. Chalk as for (a) above.

(c) Fingers
Method: Feel the engraving by running fingers across as well as along the groove. Chalk as above.

It is a good idea to keep a record which will reveal how accurately the chalking reflects the minutiae of surface relief. For this purpose, and any other surface detail, use methods 16–19.

### Method 16. Low-level aerial photography

*Prerequisites*

Methods 1, 6, 15

*Ingredients*

A tripod which will mount a camera at constant height above the surface, its back parallel to the surface. Johnson's monopod (Chapter 6) is probably preferable as it allows for greater area in each photograph.
A tapemeasure
Chalk

*Method*

Take photographs of chalked engraving

at suitable intervals to allow 60% overlap. Print them and use them just like conventional aerial photographs.

### Method 17. Contouring gently-sloping rock

*Prerequisites*

Methods 1, 6, 15

If the shape of the rock surface is considered relevant, the easiest way of surveying the relief is by adding the information to the tracing.

*Ingredients*

Your favourite means of levelling (see Chapter 4).

*Method*

Put chalk marks on the rock along contours at a suitable vertical interval (perhaps 100 mm); join up the spot-heights; trace these contours onto the tracing of the engraving.

### Method 18. Profile-former sections of engravings

*Prerequisites*

Methods 1, 6, 15

*Ingredients*

Rock-engraving tracing in progress

Profile-former (this is a device consisting of a series of steel needles which slide in a retaining frame)

*Method*

Press profile-former *across* the engraving at an appropriate place. Using the profile-former as a template, draw the profile onto the plastic adjacent to—but separate from—the tracing of the engraving.

### Method 19. Erosional 'blisters' in rock

*Prerequisites*

Methods 1, 6, 15

*Ingredients*

Engraving tracing in progress

Chalk

Tapper

*Method*

Some rocks suffer from a particular sort of weathering which forces up 'blisters' of rock in localised areas. These areas are particularly fragile. They are located because, when the surface is tapped, a deeper, hollow, booming noise is produced. The best tapper I have yet found is a Perspex umbrella handle. The booming areas are chalked onto the rock where they occur, and this area is traced onto the same tracing as is used for all the other information.

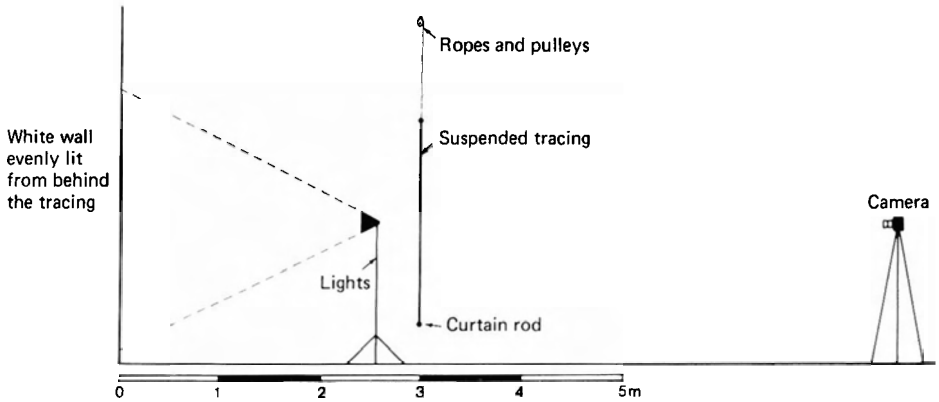



*Fig. 16*
***Equipment set up for photographing tracings.***

### Method 20. Photographic reduction of tracings

*Prerequisites*

Method 9 or 10 or 15

*Ingredients*

Tracings to be photographed

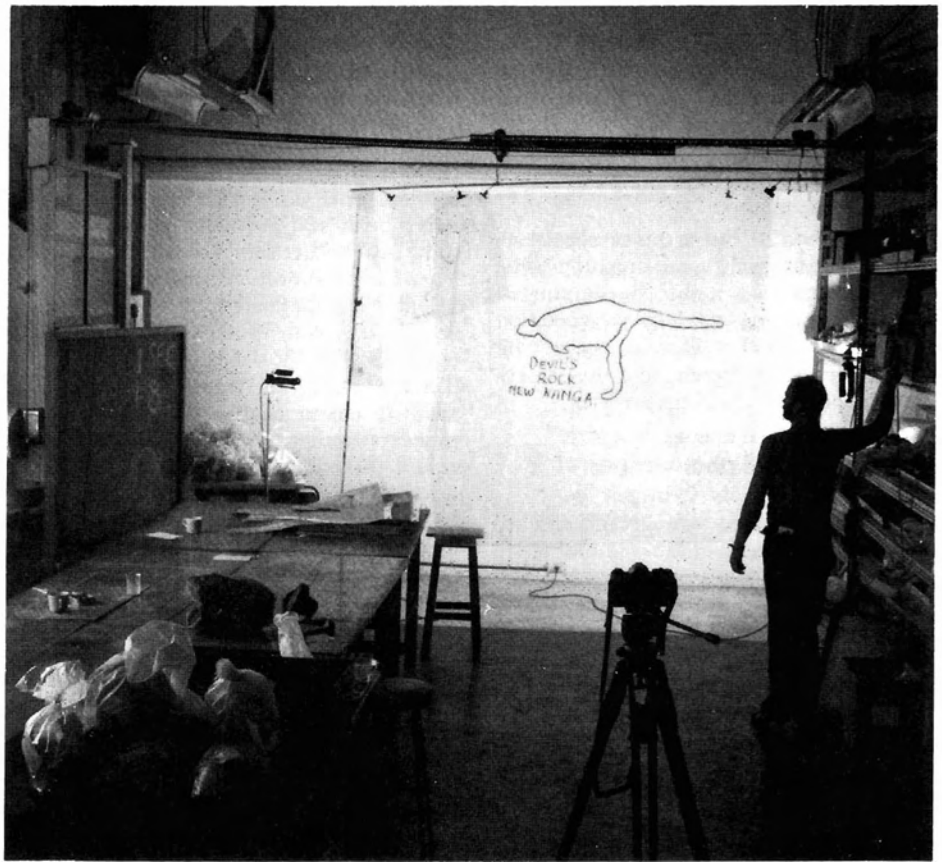
Suitable equipped laboratory

Camera, film, etc.

*Laboratory set-up*

The following dimensions are those which fit a 2-metre tracing onto the width of a 35 mm photograph, when using a 55 mm lens. The tracing is suspended from a curtain rail 3 m long. The curtain

*Fig. 17*
*Photographing a tracing.*



rail is suspended from the roof by clothes-line attached to a system of pulleys so it may be lowered for reloading. Six bull-dog clips or clothes pegs are attached to the curtain rail by elastic bands. From them the tracing is hung. The rubber bands allow tension to be adjusted so the tracing is kept flat. Another curtain rail hangs by clips and rubber bands from the bottom of the tracing. The tracing's top is 2.4 m above the floor; its bottom is 0.4 m above the floor (Fig. 16). The camera is placed on a tripod 1.4 m high at a distance 5 m in front of the tracing. The tracing position is 3 m in front of a white-painted wall, 3.3 m high and wide. This wall is illuminated by lights which shine from *behind* the tracing. A standard scale is hung beside the tracing, and appears in each photograph. The room this is set up in must be about 10 m by 4 m by 4 m. It can be used for other things so long as there is a mark on the floor indicating the tripod position. The suspending curtain rail can be raised out of the way (Fig. 17).

*Method*

Set up camera with suitable film. Suspend the first tracing. Check that it is the right way round (the writing on it makes that easy). Adjust the clips and elastic till free of wrinkles. Raise to correct position. Switch on lights. Check focus, exposure, and what is in the camera's viewfinder. Take photograph. Repeat for next tracing.

### Method 21. Photographing painted tracings (see method 11)

As in method 20, but in this case, because the tracing was made using opaque paints, not translucent inks, it must be illuminated from in front. It may not be easy to position the lights so that they illumine the tracing but do not reflect straight into the camera from the polythene's shiny surface.

### Method 22. Field photography of prehistoric art

Most prehistoric art is difficult to photograph at all, and impossible to photograph well. I shall leave the production of good photographs to competent photographers using large-format cameras. In this section I shall restrict myself to the problems of an average photographer faced with prehistoric art.

A photograph will record what the camera is pointed at with varying degrees of adequacy, depending on the technical skill of the photographer. It is necessary to have reasonably good photographs of as much as possible, to check the other recordings and have proof that the figures exist. It is nice to have a few good photographs as pretties for publication or slides. The best photographs of any one figure are taken with the camera-back parallel to the surface of the painting; the best photographs of a site show the whole site. It is sometimes difficult to compromise between the two; the answer is a wide-angle shot of the whole *and* several details. Best of all, take a series of overlapping shots from one stance. The prints can be glued together giving the overview; each individual photograph has detail.

(a) *Scales*

A photograph should contain a size scale and colour scale. The colour scale enables allowances to be made for different light conditions. The size scale should be such as to reveal any tilt the camera has, and must therefore work in two dimensions; two ordinary photographic scales mounted as sides of a square of paper of known size would do. The scale on the photograph shows how much the picture is distorted, and which distortion can be at least partially corrected by tilting the screen on which a slide is projected, or the base-board of the enlarger, until the scale comes square again.

(b) *Colour*

If you take the same drawing at different times of day there is a good chance that the photographs will turn out different colours. Different films make different colours; two prints from the same negative have different colours. This variation is a good thing for many purposes; particularly some details show up under some conditions, others when the conditions are changed.

There is a popular supposition that there is 'correct' colour. Such a thing does exist, but it is entirely subjective. The correct colour is the colour you like. Human eyes adapt to colour change, and after a short time we accept as *white* whatever light colour there is most of around. In a leafy wood we see the light as white when it is 'really' green. It is possible for one person to see different shades with each eye. If one eye has been in sunlight for some time, the other in shade, then they have adapted to different norms and see different colours. So use whatever colour film gives you the results you want.

(c) *Filters*

In method 7 I pointed out that the use of varied colour lights and glasses shows up some lines, hides others. The extremes available to photography are ultraviolet and infra-red. Infra-red needs special film; ultraviolet only needs a special filter because on all but heavily overcast days there is plenty of ultraviolet light about, and colour films are sensitive to it. But you need a filter which will cut out all visible light and let through the ultraviolet. It looks a deep purple colour. Open the aperture five stops.

(d) *Lighting*

On the whole, if you have found a way of *seeing* something you wish to photograph, just repeat those ideal conditions for the camera, and it may well work.

(e) *Contrast*

Most of the art I deal with is very faint, and I try to find a film which will give me high contrast. It seems generally true that fast films have high contrast, slow ones are fine-grained but of low contrast. Given expert professional attention, it is possible to 'bump up' the rating of a film so that it is even faster and more contrasty. I sometimes use Ektachrome 200 but expose it as 600 ASA. I get it developed by professional developers who make allowances by varying the developing, and am surprised by the good results.

### Method 23. Pager recording, retouching photographs

*Prerequisites*

Methods 1 and 6

*Ingredients*

Black-and-white photographs of the art enlarged to precisely life size

Colour paints and brushes

*Method*

Take the life-size prints to the site, and carefully paint in the colour of the art on the black-and-white print.

This method worked superbly for Harald Pager (1971) in southern Africa. It has never been tried, so far as I know, in Australia. The size of the Australian art, and the costs which would go with it, are a little daunting.

### Method 24. Brandl recording, retouching photographs

Eric Brandl used a method of retouching photographs for publication where he drew in Indian ink on photographic prints, and then bleached out the photographs (Brandl, 1973: 71).

### Method 25. Alfoil casting

There are many methods of casting rock engravings. Most of them are expensive and

potentially dangerous to the engraving. They should only be attempted with permission of the relevant State authorities and by persons suitably skilled, like museum preparators.

The technique described here is not a rival to those specialist techniques. It is intended for the non-specialist art recorder. This technique is based on the malleable nature of aluminium kitchen foil. School children's cultures have long included the knowledge that silver paper (as aluminium foil used to be called) can be made to conform so closely to the surface of a coin that the design is visible. The design shows through in so much detail that a foil-covered copper coin may be mistaken for a silver one of approximately the same size. The underneath surface of the foil—which is actually in contact with the coin—provides a very close reproduction in negative of the surface detail. The detail is certainly well within the order represented by the ear or mouth of royalty on a small coin; there should be no doubt that millimetre-sized detail will be reproduced—which is an accuracy of one part in a thousand of a metre-sized engraving.

*Ingredients*

These materials are available under a variety of trade-names; I have no preferences of one over the others.

1 roll aluminium kitchen foil

1 roll masking tape

1 aerosol can spray adhesive

Newspaper, other paper or cloth to cover the cast area three times over

Foam plastic sheeting to cover cast area twice; suggest 1 cm thickness of the spongy plastic they make into mattresses

Light-weight board size of cast area for carrying the cast

Stiff brushes, various sizes and textures; for tamping the foil to the rock

Scissors.

*Method*

(a) Brush the area to be cast lightly to remove leaves, dust or other detritus.

(b) Cut a conveniently sized sheet of foil and place it on a portion of the area. It may be loosely attached to the rock—especially under windy conditions—using weights or masking tape.

(c) Repeat (b) until the whole area is covered. At this stage the sheets of foil should not overlap; any tiny gaps between sheets will be filled later.

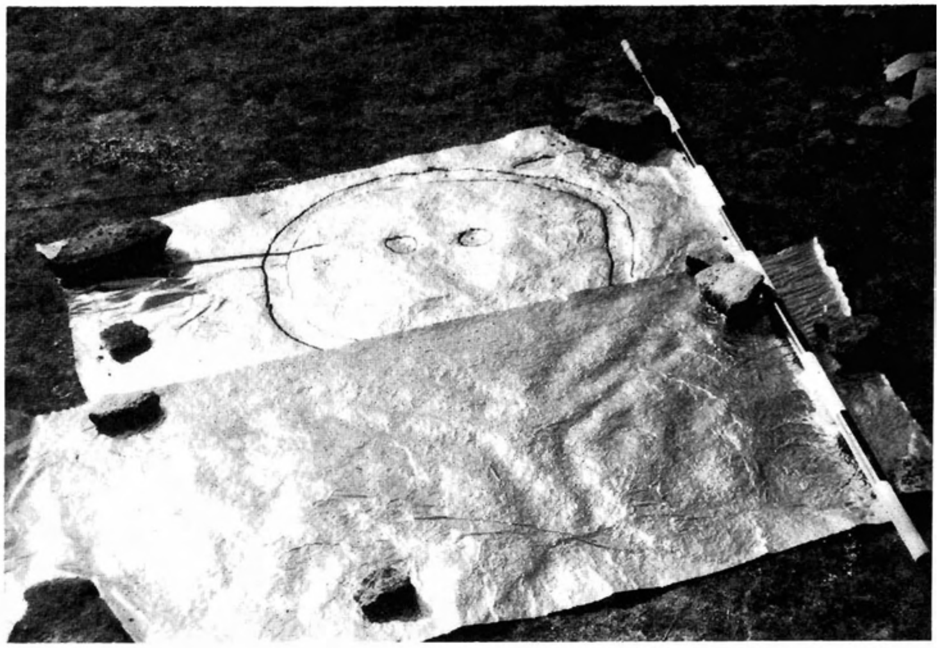


*Fig. 18*
*Foil placed over engravings has been 'walked-in'. The engraving has been drawn on one sheet of foil. Scale in decimetres.*

(d) Tamp the foil to the rock till it conforms to the surface. Feet, fingers, brushes of various sorts work; the choice of tamper should depend on local conditions. The action of tamping is perpendicular to the surface; oblique tamping is likely to tear the foil. This process stretches the foil and moves it about a little until it settles down; some adjustment of the tape or weights may be needed (Fig. 18).

(e) It is now necessary to build up the foil to a thickness of three or more sheets. Small sheets of foil are sprayed with the spray adhesive (read the instructions on the can). Tamp these smaller sheets one at a time onto the first layer until the whole area is covered to a thickness of at least three layers.

(f) Reinforce the *deepest* grooves with strips of masking tape. Use tape to strengthen the edges of the foil.

(g) By this stage there should be no possibility of holes or cracks remaining through the foil, so tougher glue may be used if desired. The further stages are intended only to make the aluminium surface tough enough for transportation. Three layers of paper or cloth, each glued on separately, seem the minimum.

(h) Once the cast is considered thick enough it may be removed from the rock. The cast is protected with foam plastic on both surfaces, and the whole sandwich strapped or taped onto a carrying board, for transportation back to a laboratory where,

(i) as soon as possible the cast—now a mould—should be used to produce a fibreglass or other permanent and robust positive reproduction of the engraving.

*Comments*

(a) So far this technique has been used successfully on areas up to 1 metre square: in larger sizes the problem is transportation.

(b) It seems best for grooves up to 1 cm or so deep; for greater relief the problem again is transportation.

(c) The *detail* obtained depends largely on the methods of tamping; it is suggested that a battery of tampers be taken into the field till experience will demonstrate the most suitable one. Detail down to a texture level—where sandstone smoothed by grinding is distinguishable from unground areas—is readily obtained.

(d) The use of aluminium foil has one advantage unconnected to the casting process. In the Sydney area, at least, many engravings are almost invisible until they are wet, when light reflected by the now shiny surface

reveals the engraving. The first four stages of casting as outlined above effectively make the surface shiny and thus sometimes reveal previously unnoticed detail.

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*Note:* Chapter submitted in 1979. Revised in June 1980.

# Chapter 10

# Geoarchaeology in Australia

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In this short contribution I outline the role that geomorphology can play in the study of Australian archaeological sites by briefly reviewing the published literature on this topic and then discussing the approach and methods that I have used in my own research. In this context geomorphology is taken to cover not only the study of landforms and landforming processes at all scales but also investigations of the stratigraphy, composition and sedimentology of deposits in archaeological sites. This field of study is perhaps more aptly called 'geoarchaeology', a name coined in the United Kingdom to cover a new discipline that is emerging. It is primarily concerned with the context in which archaeological remains are found and draws upon the theories and methods of geomorphology, pedology, geology and archaeology (Davidson & Shackley, 1976).

Clearly, it is beyond the scope of this chapter to cover Australian landforms and landforming processes in detail. A series of texts providing an introduction to systematic geomorphology has been published by Australian National University Press. Those on coasts (Bird, 1972), humid landforms (Douglas, 1977), desert landforms (Mabbutt, 1977) and structural landforms (Twidale, 1971) are particularly useful, especially as they were written by Australian-based geomorphologists and are illustrated with more Australian examples than are most other introductory texts. The chapters on physical geography in Jeans (1977) provide a more general introduction to Australian landforms.

Of more specific interest are recent papers on late Quaternary geomorphology and palaeoenvironment which summarise what is known of the changing landscape to which the Aboriginal inhabitants of the continent were continually adapting (see Bowler 1975, 1976; Bowler *et al.*, 1970, 1976). The late Quaternary was a time of fluctuating sea levels, which again must have profoundly affected the patterns of Aboriginal settlement and land use (see, for example, Bowdler, 1977; Chappell, 1976; Chappell & Thom, 1977; Jennings, 1971a; Lampert & Hughes, 1974).

Few detailed geomorphological investigations of Australian prehistoric archaeological sites have been undertaken. Of the published reports of such studies about half have been concerned with open sites in south-eastern Australia and the rest with rock shelter and cave sites spread across the continent. In the case of studies of open archaeological sites, most have dealt with sites on transverse dunes (or lunettes) along the shores of generally now-dry lakes in western New South Wales (Bowler, 1970a; Bowler *et al.*, 1970) and along the Murray River in Victoria (Macumber, 1977; Macumber & Thorne, 1975), or with sites in river terraces along the Maribyrnong River and its tributaries in Victoria (Bowler, 1970b; Bowler *et al.*, 1967; Joyce & Anderson, 1976). These investigations were aimed at establishing the ages of the sites and at reconstructing the palaeoenvironments of the landscapes in which the sites were set.

Of those studies concerned with shelter and cave sites most again were aimed primarily at reconstructing palaeoenvironments although in one ot two cases the role that human occupation of the sites may have had in influencing their geomorphic histories was also considered. The methods used in these studies were modelled on methods of sediment analyses developed for cave and shelter archaeological sites in the northern hemisphere (see, for example, Butzer, 1972, chapter 12, and Laville in Davidson & Shackley, 1976).

At Kenniff Cave and the Tombs in southern Queensland (Mulvaney & Joyce, 1965), Joyce investigated the origins of these sandstone shelters and the composition and depositional histories of their contained deposits. Changes in the nature and rates of deposition and in site usage were explained in terms of climatic change, especially fluctuating aridity, although the possibility of human influence was raised but not tested. In view of subsequent studies carried out on similar shelters elsewhere in eastern Australia and reviewed briefly in this chapter it seems likely that the impact of human occupation of these shelters on their geomorphic histories has been greatly underrated.

At Capertee in New South Wales, Walker (1964a, 1964b) studied the sediments in the archaeological deposits in a number of sandstone shelters and concluded that they were largely derived from slope wash, and that marked differences between the shelter deposits and the surrounding slope mantle were due to human occupation. In his reinvestigation of the Capertee shelters Johnson (1979) has convincingly argued that the sediments in the deposits accumulated as the result of accelerated erosion on the slopes above the shelters brought on by a regime of regular Aboriginal firing.

Sedimentological investigations at two limestone caves, Koonalda on the Nullarbor Plain in South Australia (Frank, 1971a, 1971b) and Devil's Lair in the south-west of Western Australia (Shackley, 1978), were aimed primarily at reconstructing late Quaternary environments for the surrounding landscapes. In both cases the conclusion was that the sediments contained no evidence for a substantial difference between the late Quaternary environment and that presently existing.

In his study of archaeological sites in shelters formed in calcarenite cliffs along the lower Murray River in South Australia Twidale was able to demonstrate a relationship between human occupation of the shelters and their geomorphic development (Twidale, 1964; Mulvaney *et al.*, 1964).

Jennings (1971b) undertook a geomorphological study of the Burrill Lake shelter on the south coast of New South Wales which was concerned with determining the origins and history of accumulation of the sediments in the shelter deposit and in the

gully fill shoreward of the site. The results of this study proved useful to Lampert (1971) in his interpretation of the archaeology of the site and subsequently to my own interpretation of its geomorphic history (Hughes, 1977).

## A GEOARCHAEOLOGICAL APPROACH TO THE STUDY OF AUSTRALIAN SITES

Since 1971 I have been involved in a number of research projects in Australian archaeology where a geomorphological approach has been used to advantage in studying prehistory at both the site-specific and regional levels (see, for example, Hughes, 1977, 1978; Hughes & Lampert, 1977; Hughes & Sullivan, 1974; Lampert & Hughes, 1974). In the rest of this chapter I discuss the general applicability of the geomorphological approach that I have used specifically to the study of archaeological sites. I would argue that in order to more fully understand the evidence contained in archaeological deposits the *depositional* histories of such deposits and the *post-depositional* changes that have affected them must also be considered. Depositional history is taken to concern such things as the origin and mode of deposition of the various components, their rates of accumulation and the relationships between these and site usage and on-site and off-site environment. Post-depositional history concerns such things as the decay of the organic components, disturbance, erosion, settling and compaction and their relationship to site usage and environment. Any study of the geomorphology of a site must therefore involve a detailed consideration of the site as a whole and its surroundings, and of the stratigraphy and bulk composition of its contained archaeological deposit.

The utility of this approach can best be illustrated using examples from sites I have investigated. Once the bulk composition of a particular deposit has been determined in detail changes with depth and across the site in say the amount and state of preservation of shell can be described. It is often possible to account for these changes, in gross terms at least, as resulting from differences in the decay regimes operating within the deposit. In this way I have found that in open shell middens with highly permeable matrices of dune sand (for example Bass Point) percolating rainwater can readily dissolve shell and remove it in solution and this explains why shell in such sites seldom survives more than about 3500 years. In contrast, at sites subject to the same pattern of rainfall but where the deposits have relatively impermeable matrices, these may contain well preserved shell going back 7000 years to the time when shell first began to accumulate following the post-glacial recovery in sea level. This is because less water ultimately percolates through such deposits and that which does has time to take up carbonate from the shell in solution and hence become chemically less aggressive as it passes through. An example of such a site is Currarong shelter 2 where most of the shell midden lies outside the dripline. In comparable sites where additional water from run-off from the slopes above percolates through the deposits, shell may disappear very quickly such that none older than a few hundred years may survive (for example, Burrill Lake Shelter and Currarong shelter 1). Differences in the hydrological regimes also account for differences across a site: for example at the rear of sandstone shelters, where conditions are dry, shell may survive for long periods in an excellent state of preservation whereas beneath the dripline and outside the shelter little shell may have survived and that which does is usually very poorly preserved.

Detailed analyses of the sediment in an archaeological deposit, especially grain size and mineralogy, can be used in conjunction with investigations into the geomorphic setting of the site to determine the sources of such sediment. In this way I was able to show that the deposits in the sandstone shelters at Currarong and Sassafras were derived from roof-fall whereas that at Burrill Lake was a mixture of roof-fall and alluvium, the proportions changing through time in different patterns in different parts of the shelter (Figs 1 and 2). In contrast a number of shelters investigated in the Mangrove Creek catchment north of Sydney proved to have deposits which consisted largely of alluvium washed in from upslope. The sandy matrix of the open shell midden site at Bass Point was clearly derived from a Pleistocene sand sheet which lay to the south of the site and not from the adjacent beach (Table 1 and Fig. 3).

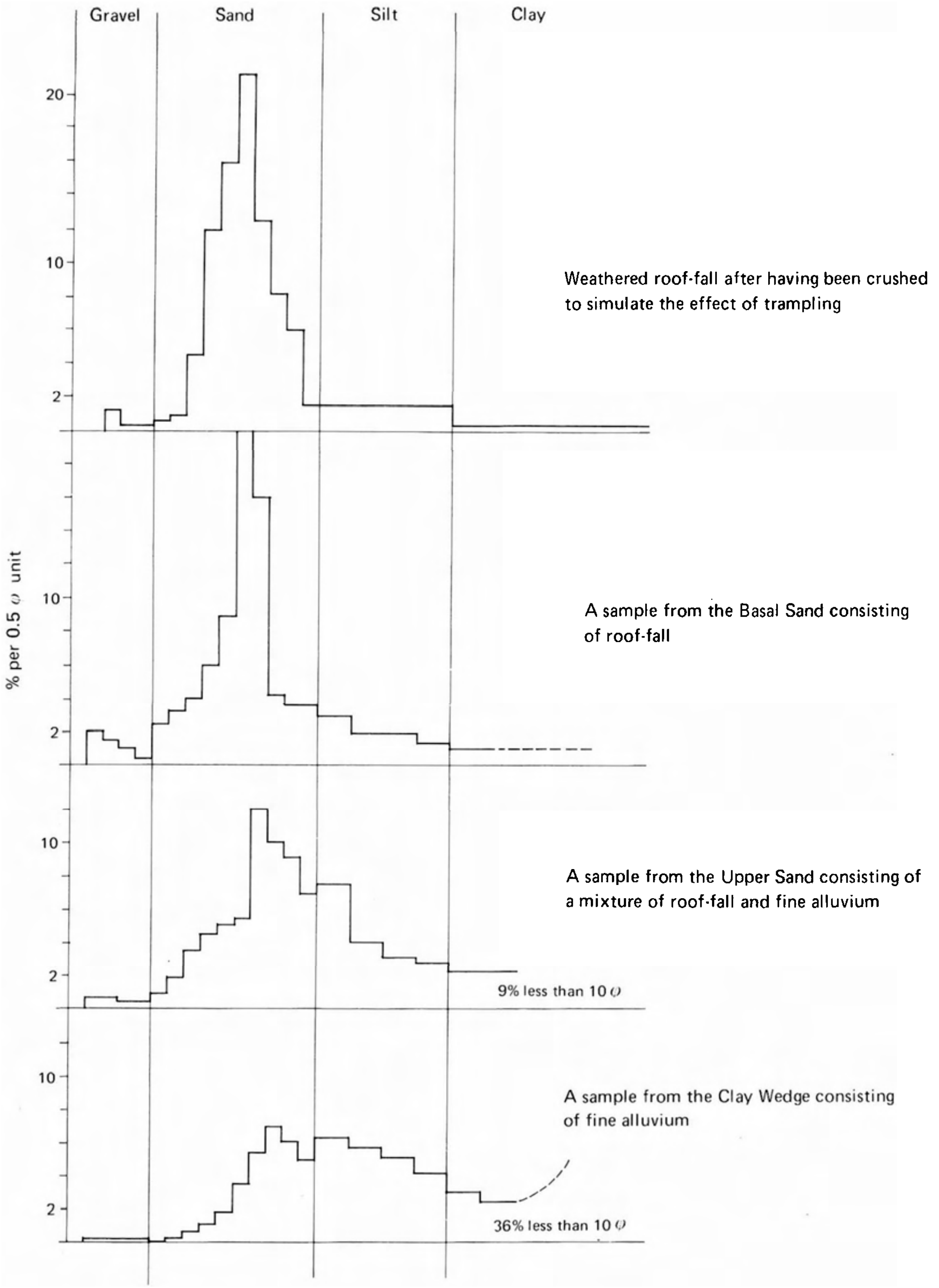
If sufficient radiocarbon dates are available, it is possible to determine the rates of accumulation of sediment and to compare them with intensity of site usage. On the basis of such comparisons I have argued that at many of these sites the geomorphic events represented by the accumulation of the archaeological deposits were what Jennings (1965: 152) has called 'quasi-natural', i.e., they were the result of natural processes which have been set in

*Table 1*

**BASS POINT; PROPERTIES OF THE SAND IN THE ARCHAEOLOGICAL DEPOSIT, PLEISTOCENE SAND SHEET, AND ON THE BEACH**

| *Sand source* | *No. of samples* | *Silt + clay (%)* | *Textural parameters (after Folk, 1974)* | *Composition* |
|---|---|---|---|---|
| Archaeological deposit | 50 | 3.0–9.0 | medium sand, moderately well to poorly sorted, strongly | >95% quartz, sub-rounded to rounded. No iron |
| Pleistocene sand sheet | 5 | 0.3–9.0 | fine skewed and very to extremely leptokurtic | staining; <5% dark minerals, all in the finer than medium sand grades |
| Beach | 2 | 0 | medium sand, well sorted, fine skewed and mesokurtic | about 50% quartz, sub-rounded to rounded; generally stained yellow with iron oxides; about 50% feldspar and rock fragments, angular to rounded, and dark minerals in all size grades |

*Fig. 1*
*Burrill Lake Shelter: histograms for the grain size distributions of samples of sediment in the deposit and from the roof.*



motion directly or indirectly by human action. At those sites where roof-fall was the major source of sediment a direct relationship was found between the rate of accumulation of sediment (and hence the rate of roof-fall) and intensity of site usage and it was postulated that people had influenced roof-fall in the following ways:

(1) by knocking down any pre-existing layer of weathered rock,

(2) by maintaining the roof and walls in a clean state through physical contact and hence exposing the rock to further weathering,

(3) by influencing the shelter environments through changes in temperature and humidity, particularly by the lighting of fires.

The impact that the prehistoric occupants had on weathering and roof-fall is clearly important when considering the age, condition and problems of management and conservation of rock art in such shelters (Hughes, 1978).

At many of the shelters where the deposits consist of alluvium washed in from upslope, for example those in Mangrove Creek and at Capertee, a case can be argued that accumulation of alluvium reflects accelerated erosion resulting from exposure of the ground surface to rain-splash, sheet-wash and rill-wash erosion following episodic firing of the vegetation cover and ground litter by Aborigines (Hughes & Sullivan, 1981).

## SEDIMENT VERSUS SOIL

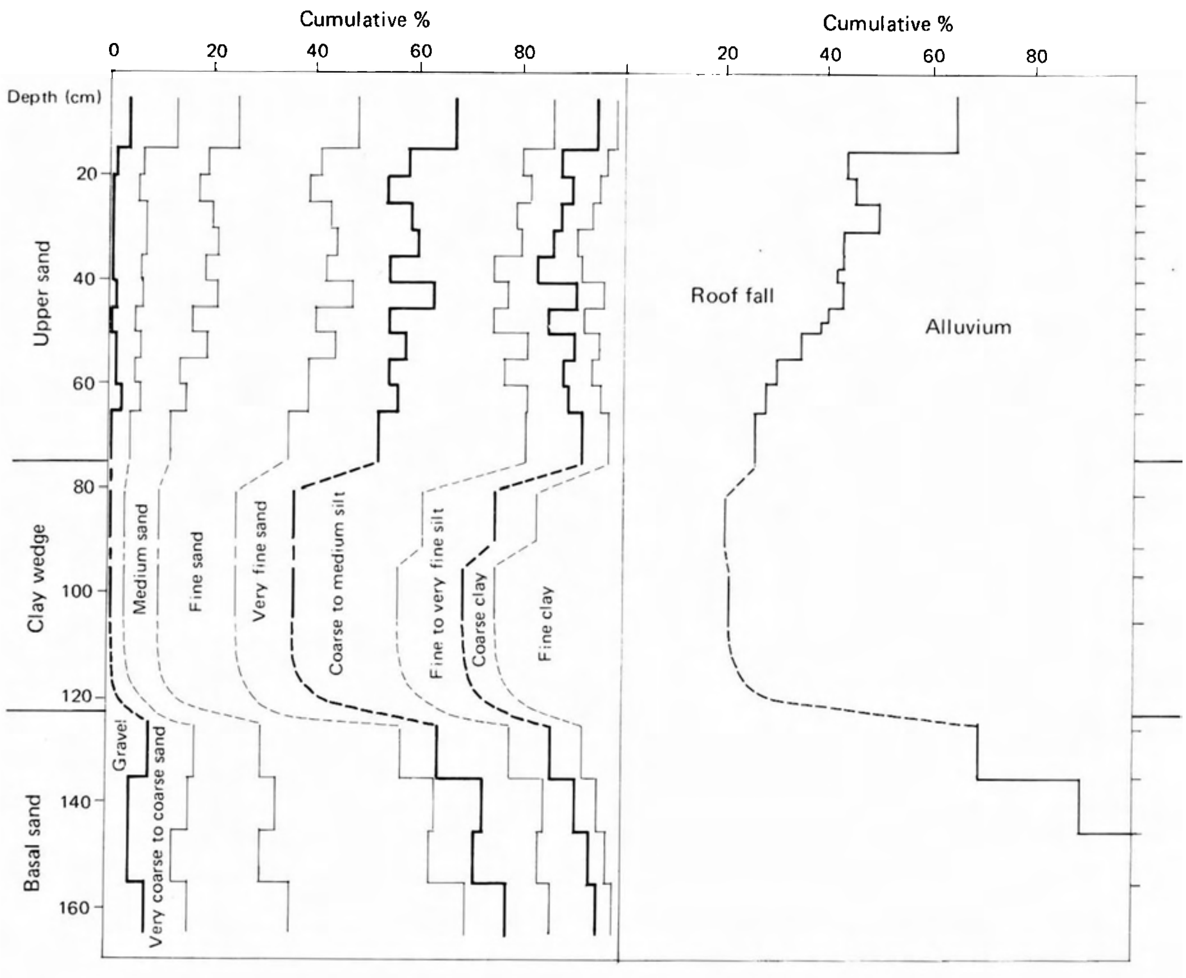
Most archaeologists use the terms sediment and soil interchangeably without any real understanding of what they mean. This is not surprising as a concise and universal definition of what is a soil and what are the soil-forming processes operating has yet to be formulated by earth scientists. A simple account of soils and how to recognise and describe them, which is particularly useful because it draws on Australian examples, is contained in Corbett's (1969) book *The Living Soil*. In studying Australian archaeological sites, especially those in rock shelters and caves, it is generally more instructive to think of their contained archaeological deposits as sediments rather than soils although cognisance must be given to the degree to which they may have been affected by soil-forming processes, particularly when considering their post-depositional histories (Magee, 1980).

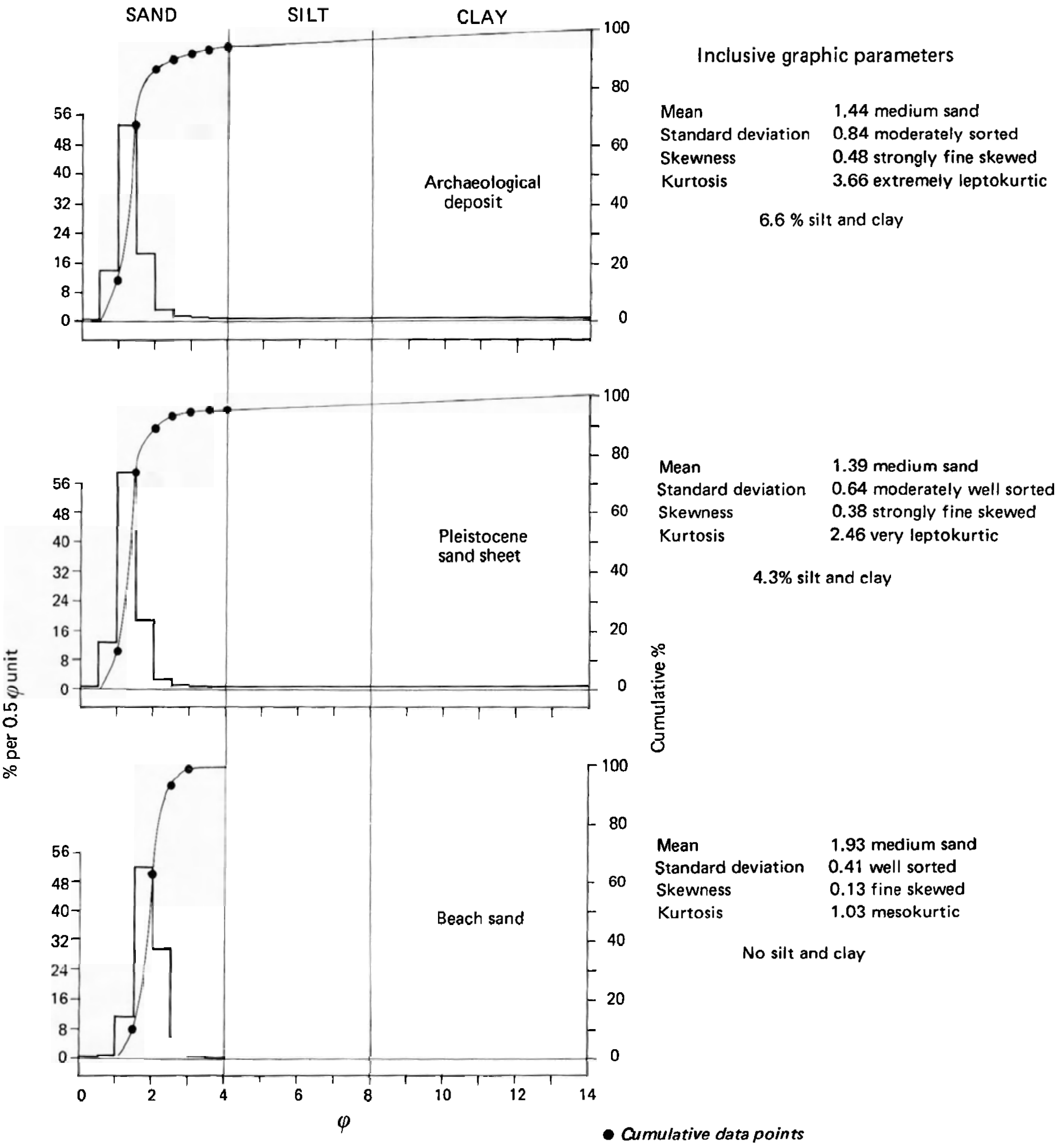
## CHARACTERISATION OF ARCHAEOLOGICAL DEPOSITS

In order to interpret the depositional and post-depositional histories of archaeological sites the following sorts of field and laboratory data should be collected.

(1) All deposits being excavated should

*Fig. 2*
*Burrill Lake Shelter: grain size distributions and proportions of roof-fall and alluvium plotted against depth for the deposit at the front of the north end of the shelter.*





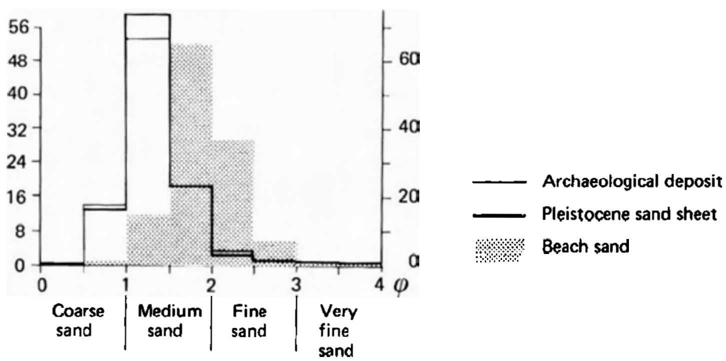




*Fig. 3*
*Bass Point shell midden: histograms, cumulative frequency curves and inclusive graphic statistics for representative samples of sediment from the archaeological deposit, the Pleistocene sand sheet and the beach. The sand fractions are replotted in the bottom graph in order to accentuate the textural differences.*

be weighed before being sieved. In this way the total weight of every stratigraphic or depth unit can be determined and, where relevant, compared with the field estimate of its volume.

(2) Oriented samples of the deposit for laboratory impregnation, thin sectioning and subsequent analysis can be collected in the course of the excavation or from the sections of the trenches after the excavations have been completed (Magee, 1980).

(3) In the sieving process everything coarser than the finest sieve (ideally 2 mm or 3 mm) can be sorted and weighted, for example whole and fragmented shell, bone, coarse charcoal fragments, stone artefacts, gravel derived from roof-fall, etc. Usually all but shell and gravel make up a negligible proportion of the total weight of the deposit. The field size classes devised by Valerie Attenbrow for sandstone shelter sites in the Mangrove Creek area of New South Wales have proved ideal for characterising the coarse rock detritus in such sites (Table 2).

(4) The weight of residue that passes through the finest sieve can be calculated by elimination of the coarse fraction. From each stratigraphic or depth unit a subsample of the residue (usually called the matrix) should be taken for further analysis in the laboratory. Usually 1 kg or a 30 by 20 cm polythene bagful will suffice. If the moisture content of the unit varies laterally or with depth further small samples of matrix should be taken (as the deposit is excavated) for moisture analysis to allow a more precise estimate of moisture content.

(5) The pH of the deposit should be measured in the field using a field testing kit such as the CSIRO soil pH test kit marketed by Inoculo Laboratories, Victoria. As the archaeologist generally only needs to know whether the deposit is very acid, slightly acid, neutral or alkaline, etc., these kits, which usually measure to the nearest 0.5 of a pH unit, are more than sufficiently sensitive. Electronic laboratory pH meters give impressive results to the nearest 0.05 of a pH unit but it is debatable what these results mean in terms of site environment. For example, pH can change markedly when sediment is stored even for short periods in a polythene bag, and varies considerably with the degree of dilution by water.

(6) Once in the laboratory the samples should be weighed, spread out to dry for at least 48 hours and then reweighed. This will give the moisture content of the matrix (expressed as weight of water lost/dry weight) and allow the total dry weight of each unit to be calculated.

(7) The Munsell colour of the air-dry matrix should then be noted. Care should be taken in interpreting stratigraphic sequences on the basis of field colour alone, as colour can vary markedly with only small changes in moisture content.

(8) There are numerous kinds of analyses that can be carried out on the samples of matrix. The physical and chemical methods that I have used are discussed in detail in Hughes (1977: 20–7, 95, 162 and Appendix I) and are summarised in Hughes (1980). Other methods are outlined in the Australian case studies mentioned above and in Shackley's (1975) book on analytical methods in the study of archaeological sediments. A wealth of information can be gained from the analysis of thin sections of samples of impregnated deposit using binocular microscope, X-radiography, scanning electron microscopy and other methods (Magee, 1980). However, as Magee stresses, the preparation of the samples and their subsequent analysis is a specialised, expensive and time-consuming process that only a few institutions in Australia are capable of undertaking. For these reasons thin section analysis should only be considered for long-term archaeological projects of an interdisciplinary nature.

## LABORATORY ANALYSES

The following laboratory analyses I consider essential in characterising archaeological deposits.

### Determination of finely divided calcium carbonate

Finely divided calcium carbonate can occur in the matrix of archaeological deposits in several forms, for example shell, limestone and secondary soil carbonate. A simple, rapid gravimetric method has been developed by Bauer *et al.*, (1972) which, when used with a sensitive top-loading balance and duplicate samples, can give results accurate to the nearest 1 per cent. I have used this method in a modified form suitable for less accurate balances such as those used in most archaeology laboratories.

(1) Pour about 15–25 ml of 5N HCl (50% concentration) into a 50 ml beaker.

*Table 2*

**GRAIN SIZE SCALE**

| *Diameter (mm)* | *phi (φ)* | | *Wentworth size class* | *Field size class (Attenbrow)* |
|---|---|---|---|---|
| 4096.0 | −12.0 | | | |
| 1024.0 | −10.0 | GRAVEL | boulder | boulder (>400 mm) |
| 256.0 | −8.0 | GRAVEL | cobble | coarse rubble (150–400 mm) |
| 64.0 | −6.0 | GRAVEL | pebble | fine rubble (9–150 mm) |
| 32.0 | −5.0 | GRAVEL | pebble | fine rubble (9–150 mm) |
| 16.0 | −4.0 | GRAVEL | pebble | fine rubble (9–150 mm) |
| 8.0 | −3.0 | GRAVEL | pebble | gravel (3–9 mm) |
| 4.0 | −2.0 | GRAVEL | pebble | gravel (3–9 mm) |
| 2.00 | −1.0 | GRAVEL | granule | |
| 1.00 | 0.0 | SAND | very coarse sand | |
| 0.50 | 1.0 | SAND | coarse sand | |
| 0.25 | 2.0 | SAND | medium sand | |
| 0.125 | 3.0 | SAND | fine sand | |
| 0.0625 | 4.0 | SAND | very fine sand | |
| 0.031 | 5.0 | SILT | coarse silt | |
| 0.0156 | 6.0 | SILT | medium silt | |
| 0.0078 | 7.0 | SILT | fine silt | |
| 0.0039 | 8.0 | SILT | very fine silt | |
| 0.0020 | 9.0 | CLAY | coarse clay | |
| 0.00098 | 10.0 | CLAY | coarse clay | |
| 0.00049 | 11.0 | CLAY | fine clay | |
| 0.00024 | 12.0 | CLAY | fine clay | |
| 0.00012 | 13.0 | CLAY | | |
| 0.00006 | 14.0 | CLAY | | |

(2) Place an empty porcelain crucible bottom-down on the top of the beaker and weigh the combination (i.e., beaker, acid and crucible)—to the nearest 0.05 g or preferably 0.01 g—on a top-loading balance (W1).

(3) Place about 2 g of matrix in the crucible, making sure first that it has been ground down to less than 2 mm particle size, and weigh the combination (W2).

(4) Gently pour the sample of deposit into the beaker, replace the crucible on top to catch any splashes or spray, and gently swirl until the reaction is complete, normally after 10–30 minutes.

(5) Reweigh without delay once the reaction is complete (W3). The percentage of calcium carbonate is calculated as follows:

$$\text{percentage } CaCO_3 = \frac{(W2 - W3 \times 227.4}{(W2 - W1)}$$

## Determination of other organic matter

The organic matter other than shell and bone generally consists of humus derived from the decay of soft plant and animal remains and finely divided charcoal. An excellent popular account of organic matter in soils that is relevant to an understanding of organic matter in archaeological deposits is given in the CSIRO booklet on organic matter and soils (Handreck, 1979). The simplest method of determining this organic matter is the loss-on-ignition method whereby duplicate 2–3 g sub-samples are ignited in a muffle furnace for 1 hour at 650°C. Ignition at such low temperature does not lead to the loss of $CO_2$ from any finely divided shell or other carbonate in the sediment. One serious disadvantage of this method is that if the sediments contain clay this will undergo some breakdown due to the loss of hydroxyl ions and strongly bonded water. This is generally not a problem in coastal sites where the matric is dune sand, and in the case of sediments from sandstone shelter sites in eastern Australia I have found experimentally that by subtracting 12% of the clay content (expressed as a percentage) a reasonable estimate of the organic matter content can be obtained.

The organic carbon content can be accurately determined using fairly simple chemical methods (e.g., the Walkley-Black method as described by Allison, 1965: 1372–5). However, it is not possible to estimate total organic matter content from these organic carbon values with any certainty.

## Characterisation of the inorganic or sediment fraction

The most informative analyses that can readily be undertaken are those of mineralogy and grain size although grain shape and grain surface textures commonly provide useful information relating to the depositional and post-depositional histories of archaeological deposits.

The methods of grain size analysis that can be used for archaeological sediments are discussed fully by Shackley (1975), Folk (1974) and Day (1965). The most common method used for analysing the sand and gravel fractions is dry sieving and the silt and clay fractions are generally analysed by the pipette or hydrometer methods. The grain-size scale that I use is the phi ($\phi$) scale conversion of the Wentworth scale, as shown in Table 2 (Folk, 1974: 25). The results of grain size analyses can be expressed in a variety of ways (Folk, 1974; Shackley, 1972, 1975).

(1) Histograms which show the percentage of grain in each size class. These can only be used to give a visual impression of the sediment but are particularly useful at demonstrating bimodality and polymodality such as is characteristic of many sandstone shelter deposits (Fig. 1).

(2) Cumulative frequency curves which are constructed by plotting the grain size classes used against cumulative percentage weight of the sample (Fig. 3).

(3) Statistical measures. A grain size distribution can be characterised by a set of numbers representing:
   - (a) *mean size* (a measure of central tendency of the distribution curve),
   - (b) *standard deviation* (a measure of the spread of values around the mean, or 'sorting'),
   - (c) *skewness* (a measure of the symmetry of the distribution around the mean),
   - (d) *kurtosis* (the 'peakedness' of the distribution curve).

These measures can be calculated using the method of moments or one of several graphic computational techniques for which the percentiles required can be read directly from the cumulative frequency curve. I have found the 'inclusive graphic' method developed by Folk and Ward (Folk, 1974: 44–52) to be the most useful method. For small numbers of samples the statistical parameters can be calculated by hand but standard computer programmes exist to handle large numbers of samples that will first interpolate the percentiles from the raw data and then compute the statistics. Statistical measures are only valid if applied to relatively normally distributed samples, for example dune or beach sands (Fig. 3). In my experience, they are of limited use for characterising sandstone shelter deposits firstly because these commonly consist of a mixture of coarse roof-fall and fine alluvium and hence may be bimodal or polymodal, and secondly because even where they consist solely of roof-fall they have variable gravel contents which often form a secondary mode at the coarse extreme of the distribution.

In order to show changes in grain size distribution with depth in a deposit the cumulative percentage of each sample, shown on the horizontal axis, can be plotted against depth on the vertical axis, as illustrated in Fig. 2.

The texture of a sediment can be expressed in a number of ways. Most textural classifications are based on a triangular relationship involving either the sand, silt and clay fractions or the gravel, sand and mud (silt + clay) fractions. Some of the more commonly used classifications, along with reviews of earlier systems, are outlined in Folk (1954), Link (1966) and Shepard (1954). The boundaries between textural classes can be varied according to the needs of the author. A major advantage of this approach is that the results can be shown graphically on a textural triangle.

Other systems, such as those described by Washburn, *et al.* (1963), have been devised to classify very poorly sorted sediments such as till or talus. These are all based on a four-end-member relationship involving gravel, sand, silt, and clay, and the results cannot easily be plotted.

The textural classification that I have devised to characterise sediments in sandstone shelter sites is of the latter type. This classification has proved useful in describing the main characteristics of the sediments in many sandstone shelters in the Sydney Basin and, to some extent, in distinguishing between materials from different sources.

The textural name given to a sediment depends on the relative proportions of the different fractions, starting with that fraction present in the smallest amount and

ending with the dominant fraction. Any minor fraction that makes up less than 5% of the weight of the sediment is omitted. For example, a sediment consisting of 6% gravel, 60% sand, 20% silt and 14% clay would be called gravelly clayey silty sand, whereas a sediment consisting of 2% gravel, 80% sand, 15% silt and 3% clay would be classified as a silty sand.

The modal subgrade of the dominant fraction is also included in the name where this is known. Thus if the median diameter of the sand fraction in the above examples was fine sand, their textural names would be gravelly clayey silty fine sand and silty fine sand.

## CONCLUSION

The rewards to be gained from the application of a geoarchaeological approach can be considerable in terms of understanding the histories of archaeological sites. The methods used need not be complicated; often basic field observations supplemented by simple field measurements and laboratory analyses will suffice. More sophisticated techniques should only be applied to answer specific questions which usually arise only after a broad understanding of the depositional and post-depositional history has been gained. Most archaeologists will not wish to undertake such sophisticated analyses themselves but it is hoped that the references in this paper will introduce techniques which will enable archaeologists to assess their problems and to approach 'specialists' with a better understanding of how they might be solved.

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# Chapter 11

# Stone implements

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A stone *artefact* is any piece of stone that was given its shape by a human being. A stone *implement* is an artefact that was made for a specific purpose. *Artefact* is thus the more embracing term and includes the by-products of making implements. One purpose of this chapter is to advise the fieldworker on how to collect artefacts. A second purpose is to provide the fieldworker with special knowledge to aid in the recognition of stone artefacts. It is not a guide to the typology of stone implements, a leisurely pursuit that is already catered for by publications and instructive displays in museums.

The flaking of stone is virtually a lost art. It is no longer part of our domestic and industrial material culture. Whereas a student of prehistoric pottery may transfer everyday experience to the study of prehistoric sherds, the student of stone artefacts is a novice with no knowledge of the various processes that produce finished implements from lumps of stone.

Not everyone interested in stone artefacts bothers to acquire a knowledge of the processes that produce finished implements. Many collectors interest themselves in silhouetted shapes. Consequently, the study of stone artefacts is prey to the wishful thinking of the uninstructed, who points wonderingly at a curious shape in stone, a shape that on proper analysis can be explained as a *lusus naturae* (a whim of nature). Every Australian archaeologist will be invited to look at innumerable whims of nature, and it is almost invariably stone artefacts that these whims of nature simulate. Of course the more spectacular stone implements, such as Kimberley points, are self-evidently the work of humans and can thus be identified as artefacts without the aid of the type of formal analysis presented in this chapter. But prehistorians must go beyond intuition and wrong information from pieces of stone that are not self-evidently artefacts.

## THE COMMONNESS OF STONE IMPLEMENTS

Stone artefacts are so common in Australia that no fieldworker can escape having to interpret them. Why are stone artefacts so common? Let us make some conservative suppositions and suppose that each adult made one finished implement a week, resulting in 52 implements a year. If there were 100 000 adults in Australia at any one time, they would have made a total of 5 200 000 implements a year, or just under one implement for every km² of Australia's current surface area. Since humans have been in Australia for at least 35 000 years they would, over those years, have manufactured some 24 000 implements for every km² of Australia. Now if we assume that 20 flakes are produced for every finished implement, then we must estimate that a total of half a million artefacts was manufactured per km² of Australia. Even if we were more conservative and assumed that it was only one implement a year, not one a week, that was manufactured, we remain with the still astounding figure of 10 000 artefacts per km².

Of course, most of these artefacts would have vanished—ground to sand in beaches, swept from long vanished land surfaces into alluvium, or drowned on the continental shelf by rising sea levels of the late Pleistocene. Nevertheless, these crude calculations show why there are still so many stone artefacts in Australia.

## THE USEFULNESS OF STONE ARTEFACTS

The collecting of stone artefacts is an activity that requires some justification in terms of the broader aims of archaeology. So let us digress briefly and consider their usefulness to prehistorians. We would have to list, among their uses:

(1) material evidence for the presence of humans in remote prehistoric periods,

(2) methods of dating sites, particularly surface sites, by analogy of artefact types with well dated assemblages elsewhere,

(3) implications about non-stone technological activities (e.g., wood working, skin scraping) with all that these activities further imply about material culture and economy,

(4) patterns of diffusion of ideas, by their distribution in space and time,

(5) patterns of trade, by the distribution of raw materials.

## RAW MATERIALS

The essential purpose in flaking stone is to produce a cutting edge that is sharper and harder than any that can be found in nature. To achieve this purpose the artisan selects, as raw material, rocks that are fine grained, homogeneous, and without a plane of cleavage. These rocks are called isotropic, which means that their physical properties do not vary with direction. Various silica rocks are suitable for flaking, for example:

(1) quartz,

(2) cryptocrystalline varieties of silica such as chalcedony, chert/flint,

(3) metamorphosed sandy rocks, such as quartzite, where silica has cemented the grains (silcrete),

(4) natural glasses such as volcanic obsidian and glassy meteorites (tektites).

Contrasting with isotropic rocks is shale, a rock with a pronounced plane of cleavage.

Sometimes the artisan does not flake a sharp edge but seeks to achieve an exceptionally even edge by grinding. A rock that lends itself to sharpening by grinding is greenstone. Greenstone is not much used for flaking, being low in silica and somewhat soft. However, lumps of greenstone are often trimmed by flaking into the rough shape of an axe, before the finished product is ground out.

It should be noted that flaked stone artefacts from sites that are independently known to be archaeological are almost invariably made from silica rocks with the properties outlined above. Any 'interesting' stone, supposedly flaked, should be examined to see if it is made from a silicious rock, homogeneous and with absence of cleavage. If it is not, it should be treated with suspicion.

## THE SURVIVAL OF STONE ARTEFACTS

Silicious rocks are hard, a property that appealed to the artisan. Hardness, of course, resists abrasion and so it is a property which aids the survival of prehistoric artefacts in sediments and soils. An additional property of silicious rocks that has aided their survival is their resistance to chemical corrosion. Note how many corrosive chemicals, both acid and alkali, may be stored in glass. The resistance of stone artefacts to physical and chemical destruction is why they are often the only evidence of humans to have survived from remote prehistoric periods. The fieldworker may therefore expect to find artefacts looking as fresh as the day they were made and dating from the remotest periods of the human settlement of Australia.

## COLLECTING

The methods of excavating stone artefacts do not differ from the methods used for the excavation of 'small finds' in general. Surface collecting, however, does offer special problems, chiefly because of the sheer numbers of stone artefacts that often lie around awaiting collection.

Collect only when there is a specific reason for collecting. Do not collect in the vague hope that someone, some day, might find your collection of scientific value. Stone artefacts are antiquities and therefore are subject to the laws of each state and territory. Check what these laws are before collecting.

### Where to find surface artefacts

In the more arid parts of Australia stone artefacts are readily found scattered over paddocks or exposed in blow-outs. However, much of Australia is well vegetated and the fieldworker will find that particularly poor conditions for finding stone artefacts are where there is good forest or grass cover. Nevertheless, even in a well vegetated landscape it is usually possible to find places where the surface soil has become scoured by runnels of water flowing in cattle or vehicle tracks. Search these runnels for artefacts; if they contain none it is unlikely that there are artefacts in the area of catchment for the runnels. In addition, look in road or rail cuttings, where artefacts are frequently washed out of the surface soils and left on the lower slopes of the cutting.

Above all, take advantage of ploughed paddocks; after rain, artefacts may be found washed clean, perched on little pedestals of soil that have been protected from erosion by the cover of the artefact. If all else fails, look at the stones carried up by ants and dumped on the mounds above their nests. The essential principle, in looking for surface artefacts, is to look for natural disturbances of the soil.

### Labels

It goes without saying that artefacts should be labelled with information about their provenance. It is useful to put the artefact in two plastic sandwich bags, with a label between the two bags. By doing this the artefacts can still be seen, the label does not become damp or soiled, and some protection is afforded to the delicate edges of the artefact. Excellent protection to edges is afforded if the artefact is wrapped in aluminium foil before being put in the bag. Above all, do not put artefacts together in a bag to knock against each other and create their own pseudo-secondary flaking or pseudo-use-wear.

Do not be too anxious to clean off all soil or adhering concretions. Important questions may arise about the exact stratigraphic provenance of a particular artefact. If this happens, there is nothing like adhering matrix to help settle questions.

### Sources

As well as collecting artefacts the fieldworker may wish to find the sources (perhaps even quarries) from which the raw material for making the artefacts came. A geological map of the surroundings may help in locating silicious rocks *in situ*. Remember, however, that many artefacts are made from river pebbles, and these may have been transported kilometres from their source as part of the river's bed load. So the archaeologist who wishes to locate sources is faced with a task that does not coincide with a geologist's usual interests. It is therefore important to try and locate sources while in the field and not rely on later geological advice.

## SAMPLING

It may be both desirable and possible to collect all the stone artefacts exposed on a surface site. But every fieldworker will some day have to face the methodological problems of sampling a site for its stone implements. Sampling is often forced on a fieldworker by the sheer numbers of artefacts present.

Archaeologists may want to use samples of stone artefacts to discover patterns of implement distribution within sites, examine size differences of artefacts between sites, compare proportions of implement types at different sites, and compare the uses of different raw materials at different sites. None of these comparative analyses has validity unless a proper method of sampling is used. No fieldworker can collect a representative and unbiased sample unless special methods of collecting are resorted to.

In brief, if your project requires the collection of a *sample* of stone artefacts from a surface scatter do not collect any artefacts until you have worked out a sampling strategy.

### A random sample

A method of sampling that has much to recommend it is random sampling. If a random sample is taken it is possible to use the sample to make inferences about the whole collection from which the sample was drawn. Well tried statistical methods are available for making such inferences, methods based on probability theory. The archaeologist who obtains a random sample is buying a share in a massive body of statistical method and theory.

A true random sample requires that each artefact in the scatter has an equal and independent chance of being incorporated into the sample collected. This means that not only must each artefact have an equal chance of being collected, but in addition the collection of any particular artefact in the scatter must not influence the collection of any other artefact.

To be rigorous, the only reasonable method of drawing a true random sample from a scatter of artefacts is to assign to each artefact in the scatter a unique number and then draw the sample by drawing a set of such numbers at random. The artefacts that are then collected are those whose numbers were drawn. For the purpose of making up the sample random numbers can be taken from tables or generated on a programmable calculator.

In practice it may be most inconvenient,

or even impossible, to assign numbers to artefacts as they lie in a disordered scatter on the ground. An acceptable, but less rigorous method, is to make the unit of collection not the individual artefacts but the *quadrats* or *transects* within which they lie.

### Quadrats

The idea of the quadrat is derived from ecological studies, especially vegetational analysis. A quadrat is a square (conveniently a square metre) randomly selected from a grid actually, or theoretically, laid out over the whole scatter. The squares of the grid are numbered and it is these numbers that are selected at random. As many squares are selected as prove practicable for the archaeologist to collect from. All artefacts within the selected quadrats are collected.

The method of quadrats does not yield a random sample of the scatter. Most importantly, the principle of independence is violated. So it is no substitute for a true random sample. The method of quadrats will, however, allow examination of questions of technological homogeneity within sites.

### Transects

A third method of sampling a scatter is the transect. Again, a transect will not give a random sample of the scatter, but it is easy to set up and will give an unbiased sample. To set up a transect two parallel strings are laid across the scatter, from one side to the other and all artefacts between the strings are collected. The alignment of the transect should be selected at random and as many transects can be selected as are desired.

### Collecting all artefacts

The admonition to collect all artefacts from a quadrat or transect raises real problems about the minimum sizes of artefacts to be collected. Any archaeologist who has done his or her own flaking, and especially secondary flaking, will know that the debris of flaking includes true flakes that are virtually microscopic in size. It is not, in other words, possible to collect all artefacts under all conditions.

The sample to be collected will, therefore, have to be censored by setting a size limit below which pieces of flaked stone will not be collected. A reasonable limit is to exclude all pieces that do not achieve 5 mm in at least one dimension. The censoring should be recorded and reported to anyone who may wish to study the collection.

### Special collections

The practice of sampling must not force the fieldworker into ignoring objects of special archaeological value that happen to fall outside the programme of random sampling, quadrats or transects. It may happen that the fieldworker notices a collection of flakes that has come from a single core or finds an eroding hearth with a batch of implements apparently associated together. It would be archaeologically pointless not to salvage such artefacts merely because they were not part of one's sample. All that is required of the fieldworker is to keep specially collected objects distinct from those that were collected by controlled sampling. Keeping objects that were specially collected separate will ensure that the usefulness of the sample, for making statistical inferences, will not be prejudiced.

It should, furthermore, be obvious that objects of special interest should be salvaged only after the more formal samples have been collected. If they are collected first they are precluded from appearing in the sample.

## UNDERSTANDING FLAKES AND CORES BY SELF-TUITION

The key to understanding flaked stone technology is to understand the flake and the core. Fortunately, the flake is easy to understand and has attributes that are easily described. Yet the flake's technical simplicity often masks what a portentous invention it was. There is nothing sharper and harder in nature, and once you master the simple technique of making flakes you can easily produce them at a rate of one a second.

Simple though a flake is, many misunderstandings arise from not knowing how to interpret its attributes, and those of the core from which it is detached. If you can understand the attributes of flakes and cores you will avoid confusing them with natural rocks or with finished implements.

There are two ways of learning the attributes of flakes and cores.

(1) Study a collection of prehistoric artefacts, finding among them examples that illustrate Figs 1–16 and visualising the processes that led to their production.

(2) Get a round-headed household hammer, a core of rock and flake the rock to produce the examples illustrated in Figs 1–16.

Flaking rock yourself is the best way of learning. After such self-instruction you are most unlikely to forget the properties of flakes and cores, and in particular you will learn to diagnose those special features that set finished implements apart from the waste products of flaking. Those who have never done any flaking continue to run the risk of being distracted by 'interesting' shapes that the practiced stone flaker knows to be produced fortuitously.

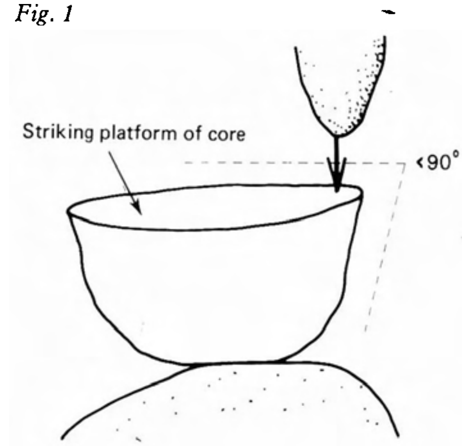
If you are going to flake stone yourself remember that lumps of industrial slag or glass may be used but that you will produce dangerously sharp splinters. The more granular products of flint or silcrete are safer (the flint from the southern coastline of Australia is ideal material). Whatever material you use, do wear leather gardening gloves to protect the fingers and goggles to protect the eyes. Remember that there is nothing sharper than a primary flake. And do not have anyone sitting near you; a flake does not fall off a struck core, it shoots off.

## ELEMENTARY FLAKING AND ITS PRODUCTS

In Figs 1–16 are illustrated some basic principles and products of stone flaking. The fieldworker should be able to identify these examples in any collection of prehistoric artefacts. To make them oneself will produce a deeper understanding.

(1) *The potential core.* Fig. 1 represents a *potential core* from which flakes have not yet been struck. Note that the angle between the top surface *(striking platform)* of this potential core and its sides is less than 90°; it is very difficult to detach flakes from cores where the angle between the striking platform and the sides is greater than 90°. The arrow represents force, in this case force applied by a *hammerstone.* The hammerstone is being directed at a point just in from the actual edge of the striking

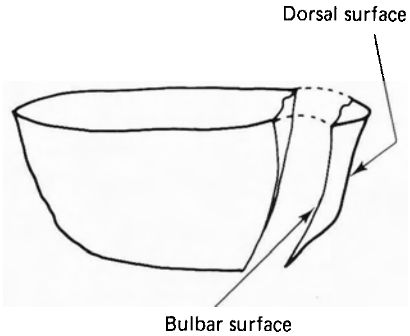
*Fig. 1*



platform. The core rests on an *anvil*. Both the hammerstone and the anvil will become pitted with use.

(2) *The flake at detachment*. Fig. 2 shows the flake at the moment of detachment from its core, it is at this stage an *unmodified* or *primary* flake. On the top of the flake is the *striking platform,* carried away from the striking platform of the core. In addition to carrying away part of the platform, the flake has carried away part of the side of the core and this surface of the flake is called the *dorsal* surface. The other surface of the flake, that was 'inside' the core, is called the *bulbar* surface (sometimes the *ventral* surface).

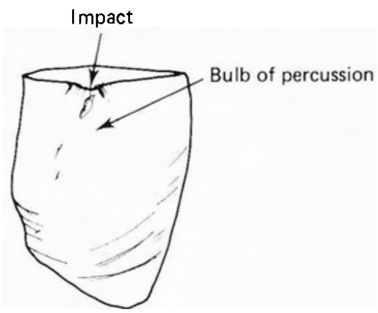
*Fig. 2*




(3) *The bulbar surface*. Fig. 3 illustrates the bulbar surface, which though smooth shows several features that are characteristic of a *conchoidal fracture,* the sort of fracture induced by a hammerstone working on silicious rock. The point of impact of the hammerstone may survive as a circular crack on the striking platform. From this point the shock waves, that detached the flake, radiated out through the core and left characteristic features on the bulbar surface, namely:

(a) *The bulb of percussion,* a raised area, cone-shaped in plan, that resembles the umbo near the hinge of certain

*Fig. 3*




bivalve molluscs (hence the term conchoidal fracture derived from the Greek word for the mussel).

(b) On the bulb of percussion there may be visible the *bulbar scar,* a mark left by a thin spall that flies off as the flake is detached.

(c) Over the bulbar surface are found *waves* or ripples which represent the dispersal of energy from the blow that detached the flake. If the waves were complete circles they would be concentric around the point of impact; on the flake they are only arcs of circles, the concavities of which point to the place of impact.

(d) *Fissures* radiate out from the point of impact and are especially noticeable near the margins of the flake. These fissures represent minute incipient splinters, air having got behind them and changed the refraction of light reflected off the surface of the flake.

(e) It is the *margin* of the flake that is the sharp part. Because the specimen we are considering is an unmodified primary flake, it has no identifiable working *edge* on its margin. But this is not to say that part of its margin could not be used immediately as an edge for cutting—there is nothing sharper in flaked stone technology than the unmodified margin of a flake.

Note that if we were presented with just the broken end of a flake we would be able to make an estimate of the size and shape of the flake from which it was broken off; we would do this by using the waves and fissures as orientating guides.

(4) One possible state of the *dorsal* surface of a flake is shown in Fig. 4. In this example the right half of the dorsal surface is a *flake scar*. The flake has carried away with it, from the core, the scar of a flake that was detached previously. Looking to the left half of the dorsal surface we see the original 'skin' of the rock that was turned into the core; this skin is called the *cortex*.

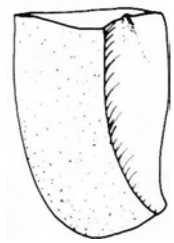
The dorsal surface of a flake can assume one of three states, depending on what had been happening to the part of the core from which the flake was detached. The three states are:

(a) all cortex, where the flake comes from a core, or part of a core, not previously flaked;

(b) part cortex and part flake scar/scars (as in Fig. 4);

(c) all flake scars.

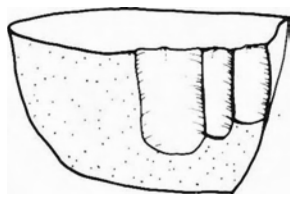
*Fig. 4*



The condition where a flake has all flake scars on its dorsal surface may be a valuable indicator of a flake being an artefact. Condition (c) is the result of repeated flaking from the same area of a core, and is a characteristic of human flaking. On the other hand, haphazard natural processes of flaking (rocks falling off cliffs, rolling in torrents) characteristically produce flakes with cortex.

(5) The core in Fig. 5 illustrates the points made in section 4 above. It can readily be seen that any further flake detached from this core could assume conditions (a), (b) or (c), depending on whether it was removed from the left, middle or right side of the core illustrated.

*Fig. 5*



Figs 6–11 illustrate the dorsal surfaces of primary flakes and show attributes that can often be troublesome to interpret.

(6) Fig. 6 shows an untroublesome flake, with the remains of three primary flake scars.

(7) Fig. 7 is superficially like Fig. 6 but shows, in addition, a *facetted* striking platform. Cores may not have plain surfaces as their striking platforms.

*Fig. 6*



*Fig. 7*



(8) At the junction of the striking platform and dorsal surface of Fig. 8 is to be seen some crushing. The crushing extends onto the dorsal surface. Such crushing can be produced by an earlier, misdirected, and unsuccessful attempt to detach the flake. The crushing should not be regarded as intentional and secondary modification of the flake.

*Fig. 8*



*Fig. 9*



(9) Fig. 9 is an elaboration of Fig. 8, and shows where a mishit with the hammerstone caused crushing, then a small flake was detached and finally the flake itself was successfully detached. Again, these features are primary.

(10) In Fig. 10 some preliminary flaking was done at right angles to the direction of the blow that detached the flake.

*Fig. 10*



*Fig. 11*



(11) The flake in Fig. 11 has carried away from the core part of an earlier striking platform.

The comments made about Figs 8–11 indicate that the flaking should be interpreted as primary. It is, however, possible to interpret such flaking as *secondary,* that is as flaking done after the flake was detached from the core. Yet, as a general rule, and unless there are compelling reasons for interpreting it as secondary, it is safer to interpret such flaking as primary. A compelling indication to the contrary would be if the flaking continued round to the primary margins of the flake.

Figs 12–15 illustrate the important process of *modification* to the primary margins of flakes. Modification may be

*Fig. 12*



*Fig. 13*



deliberate (e.g., shaping an edge by *secondary flaking*) or accidental (e.g., *use-wear,* where an edge is fractured by a chopping action). Whether or not the modification is deliberate or accidental, it is possible to identify it unambiguously as secondary modification where, as in Figs 12–15, it affects the primary margin of a flake. In other words, we can be very sure that we are dealing with secondary modification because we can define secondary modification as modification of the *primary* margin of a flake.

(12) In Fig. 12 *secondary flaking* has modified the primary margin of the flake into a smooth edge. The edge is formed by a series of miniature flake scars. Note that the flake has been flaked as though it were a core; however the word 'core' is best reserved for a flaked object that served as a source for flakes. In the case of Fig. 12 the flakes produced can best be interpreted as incidental to the shaping of the edge.

(13) In Fig. 13 a concave edge has been produced by secondary flaking on the bulbar surface.

Secondary flaking is found normally on the dorsal surfaces of flakes, in other words it is carried out by means of force exerted onto the bulbar surface. If secondary flaking is found either on the dorsal surface or on the bulbar surface, but not on both, it is said to be *unifacial.* If it is found on both surfaces it is said to be *bifacial.*

*Use-wear* can take the form of secondary flaking. But it can also be caused by abrasion, where the edge of a flake becomes striated or polished. This sort of use-wear occurs when the substance being cut by the flake is hard or dirtied by abrasive particles. Abraded use-wear often shows up to the naked eye when a concentrated source of light is reflected off the abraded surface. The detail of the wear can usually be resolved with a × 10 binocular microscope. Be sure that you are looking at abrasions and not at the incipient cracks on the bulbar surface of a flake (see fig. 3).

(14) In Fig. 14 is represented use-wear, with abrasions perpendicular to the edge and produced by a chopping action.

*Fig. 14*

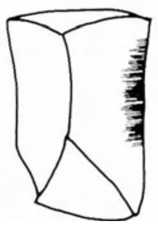


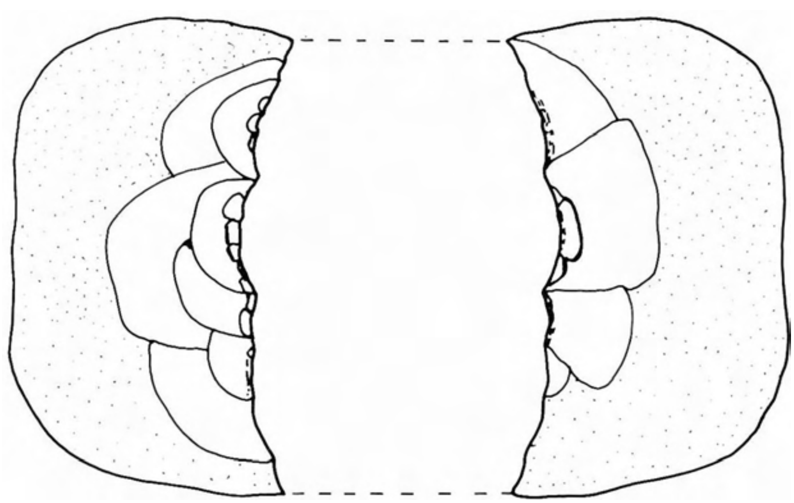
*Fig. 15*



(15) The abrasions in Fig. 15 are parallel with the edge and produced by a sawing action.

(16) Pieces of stone (that are not flakes) can be flaked implements and may also show flaked and abraded use-wear. Fig. 16 is a piece of stone with bifacial flaking, designed to produce a rough chopping edge. Such implements are aften called *core*

*Fig. 16*



*tools*. It may be difficult to decide whether such a flaked piece of stone has been shaped for use (a core tool) or taken its shape merely because it was a source of flakes (a *core* proper). Indeed it may have served the purpose of a core and then been modified into a core tool.

## ANALYTICAL FLOW CHART

By using the principles established in the previous section the fieldworker can sort any stone industry into simple technological categories. A systematic approach to sorting is valuable because at least it ensures that all pieces are examined. Fig. 17, therefore, offers one of many possible initial schemes of sorting.

Fig. 17 is an analytical flow chart that aids initial sorting in the field. Its use will ensure that the fieldworker has a good idea of what sort of stone industry is presenting itself. In using the chart, each piece of stone is allowed to flow through the chart by decision of the fieldworker. For example, Fig. 12 would be described as a piece of fractured stone—a flake—a modified flake—with secondary flaking applied for the purpose of shaping. Fig. 16 is a piece of fractured stone—a flaked piece—a core tool—(and nothing can be said about use-wear).

Some explanation of Fig. 17 is necessary.

(1) Relatively objective categories are enclosed in a box. 'Objective' means that different workers will come to the same conclusions about the categories to be assigned to the same pieces of stone. The categories that are not boxed require a higher level of interpretation, and agreements between workers will be less frequent. It has, for instance, proved difficult to get agreement in distinguishing core and core tools.

(2) *Flaked pieces* must show negative flake scars in the form of negative bulbs of percussion. It is not enough that a piece shows vague facets; these can be caused by such natural processes as the stress of rapid temperature change and have nothing to do with human flaking.

(3) *Flakes* must show bulbs of percussion. It is not enough that a piece be thin, sharp and perhaps the broken end of a flake.

(4) *Waste* will include pieces of broken core and flake that are not complete enough to meet the strict criteria applied to the previous two categories.

(5) *Damage after discard* includes such damage as being trampled on by cattle and being abraded in streams.

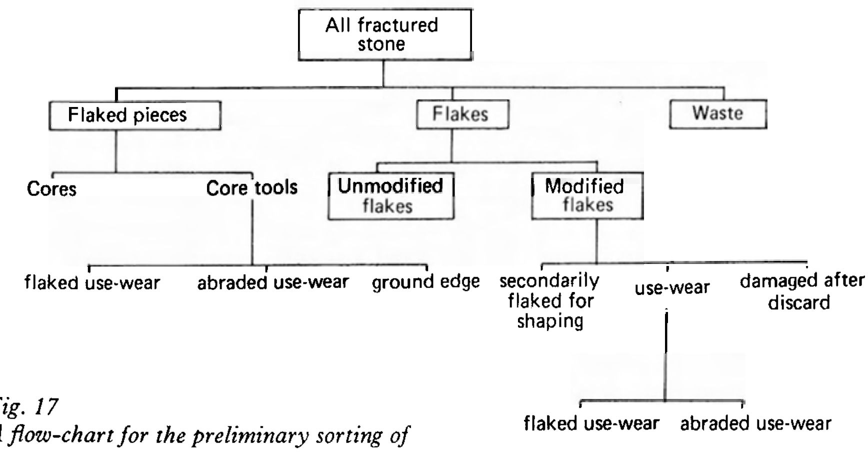



*Fig. 17*
*A flow-chart for the preliminary sorting of stone artefacts.*

## THE LIFE HISTORY OF A STONE ARTEFACT

The fieldworker may on occasions be faced with a problematical stone artefact, one that is not readily interpreted by means of the principles outlined above. Or the fieldworker may wish to take the analysis further than Fig. 17 allows.

It may help to systematically write the stone's biography by using clues observable on its surface. The aim of the biography is to narrate the sequence of events that happened to the artefact starting at the stage of raw material, continuing through the process of flaking and ending with the modifications that happened after the artefact was discarded.

The discussion has assumed that one is dealing with an artefact. Yet the exercise of writing a biography may prove especially useful when facing a stone object that could be a *lusus naturae*. Indeed, unless one can provide a stone object with a coherent

## EXAMPLE OF A STONE ARTEFACT'S BIOGRAPHY

| *The biography* | *Clues used* |
|---|---|
| A flake | bulb of percussion present |
| struck from a pebble | pebble cortex survives on dorsal surface |
| the pebble having been split first | platform of flake is not cortex |
| not the first flake from the core | dorsal surface of flake has both cortex and flake scars present |
| the artisan had difficulty detaching the flake | much battering on dorsal surface, at junction with platform |
| secondarily flaked to give an evenly curved convex edge | primary margin of flake altered by unifacial flaking on dorsal surface |
| completed artefact lay for an extended period in soil | chemical alteration of surface (patination) and staining of patination by iron salts |
| for a period was moved in soil, perhaps during soil creep | abrasion of all facets |
| the end was broken off recently | snap fracture, showing in the broken cross-section a kernel of unpatinated and unstained original rock; the broken edges of this fracture not abraded |
| artefact was placed in a bag with other artefacts and the bag crushed | irregular, bifacial flaking of both the abraded patinated and the unabraded unpatinated surfaces |

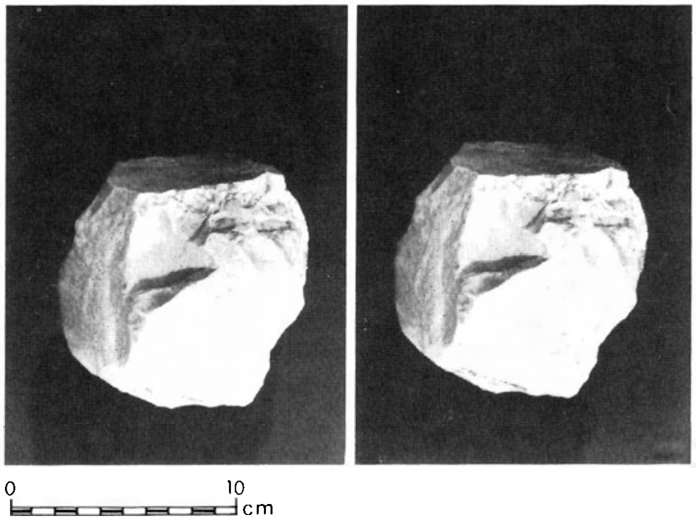



*Fig. 18*
*A horsehoof core, with intensive crushing around the striking platform.*

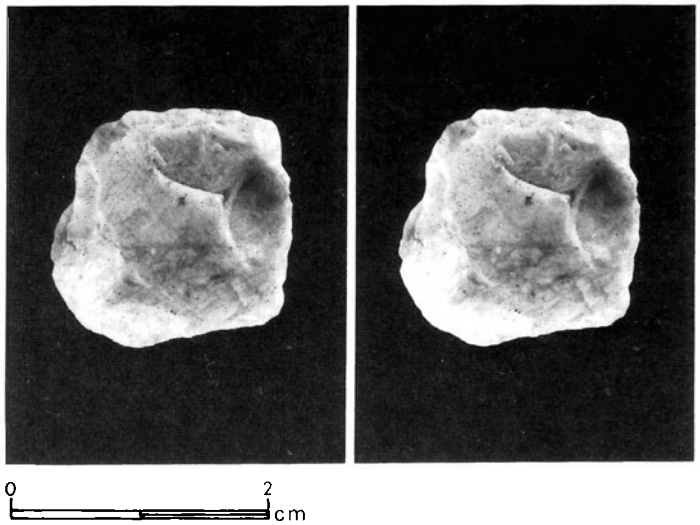



*Fig. 20*
*A miniature core, flaked bifacially from all four edges. Such objects have been called fabricators.*

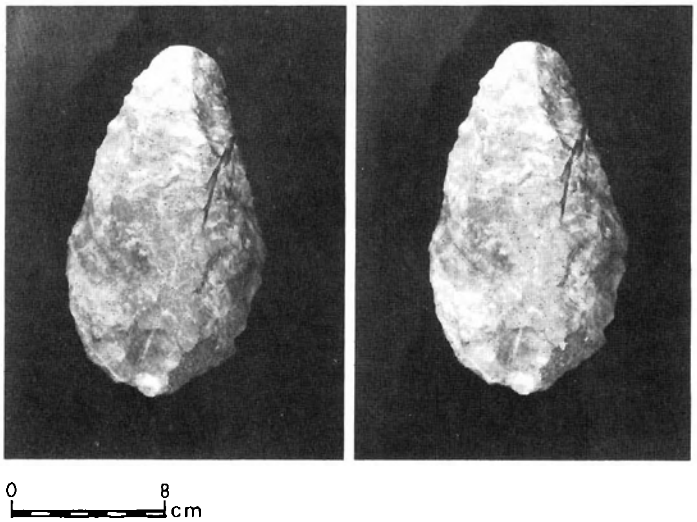



*Fig. 19*
*A pebble flaked all over one surface. The under surface is entirely cortex.*

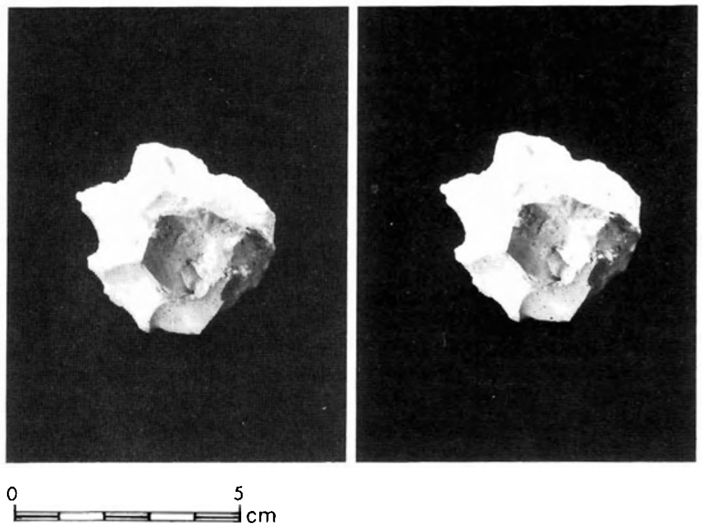



*Fig. 21*
*The base of a small core.*

narrative of events, to make up a biography, its identification as an artefact may be wishful thinking.

## FINISHED IMPLEMENTS

In Figs 18–26 are illustrated some finished implements and other artefacts. The photographs are stereo pairs and illustrate some of the technical points made in this chapter.

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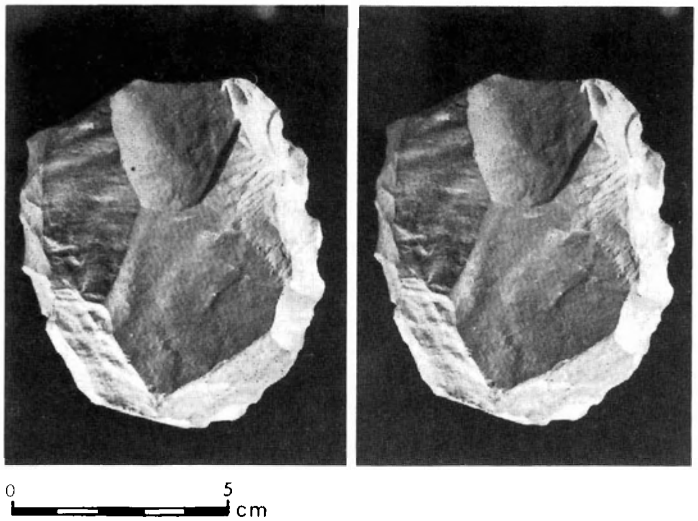



*Fig. 22*
*A large flake. Secondary flaking, on the dorsal surface, has produced a horseshoe shape.*

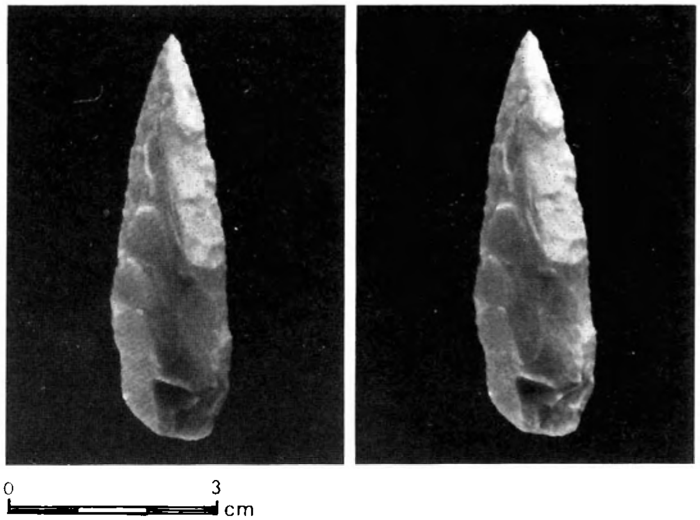



*Fig. 24*
*A flake trimmed to a point by secondary flaking.*

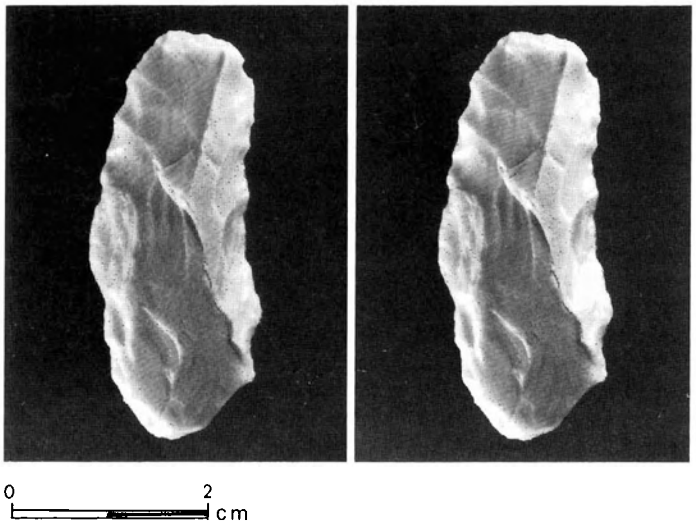
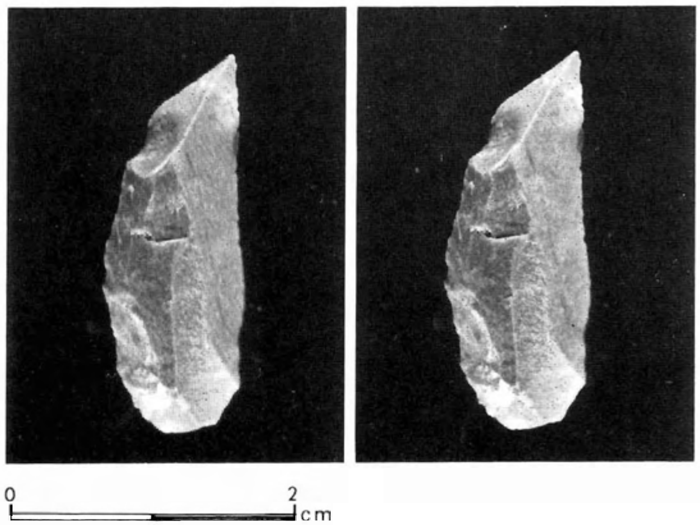



*Fig. 23*
*A small adze flake of the type mounted on the end of stick to work wood. Secondary flaking has obscured almost all the primary features of the flake.*



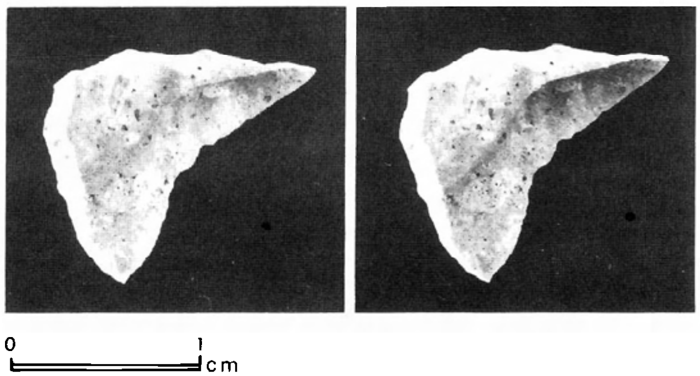




*Fig. 25 and 26*
*Flakes with blunted backs, the opposite edges sharp.*

*Note:* Chapter submitted in 1980.

# Chapter 12

# Recovery and analysis of bone in Australian archaeological sites

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Bone forms a major component of the material recovered from many archaeological sites. Usually it consists of masses of broken and burnt fragments, the discarded remains of animals collected for food, often mixed with fragments derived from non-cultural sources, such as natural deaths and the action of predators. A special situation that occasionally faces archaeologists is the excavation of human skeletons found in position of burial. In both cases the bone must be removed from its matrix, transported to the laboratory, cleaned and strengthened if necessary, identified to species in the case of animal bones, or to sex and age in the case of human remains, and finally interpreted in archaeological terms.

Many books discussing the analysis of archaeological bone are already available. Those dealing with human remains have direct relevance to the Australian situation, since the species is the same. With regard to animal bones, general works on bone identification written elsewhere in the world are inapplicable because of the unique Australian fauna. Further, many studies written by northern hemisphere archaeologists are preoccupied with animal domestication, which has little relevance to the questions posed by hunter-gatherer sites in Australia.

As yet there is no single book which illustrates the skulls and skeletons of all Australian mammals, the group most abundantly represented in Australian archaeological sites. Information about individual species or groups of mammals and other vertebrates can be found in scientific journals, but identification of animal bone fragments depends on familiarity with the taxonomy and distribution of the Australian fauna, and most importantly, on access to collections of identified skeletons.

This chapter summarises the techniques used in collecting, preserving, identifying and analysing bone recovered from archaeological sites. It should be regarded merely as an introduction to the extensive literature on the subject, rather than as a definitive statement.

## TREATMENT OF BONE IN THE FIELD

The most common situation in the field is to encounter many broken and burnt fragments of animal bone. These can be and usually are treated in the same way as other remains: left in the matrix as it is excavated and sieved, then picked out of the residue in the sieve along with stone, shell and other material. Bone is more fragile than stone, and excessive dry or wet sieving can cause damage or the loss of teeth from jaws; this is regrettable since teeth are often crucial for the identification of the species present. If the bone is in poor condition it should be excavated from the matrix before sieving, and if necessary treated with chemical hardeners as described below.

General questions of sampling apply to bone as to all other remains. Bowdler (Chapter 13) summarises sampling methods as applied to midden sites; these are equally applicable to non-midden situations. It is perhaps worth emphasising the value of bulk sampling at least a portion of the deposit being excavated. Small bone fragments, as well as tiny land snails, are often lost through sieves, and hand sorting of bulk samples can be invaluable in assessing the total faunal assemblage in a site. The extensive faunal list from Seton Rock shelter (Hope *et al.*, 1977), 27 mammal species, 40 birds, 8 reptiles, 7 marine and 10 minute terrestrial and freshwater molluscs, was identified on bone and shell fragments most of which were less than 2 cm in size. They were recovered by taking the entire matrix, except for large rocks, to the laboratory and processing the material by hand several times, both before and after washing.

While it may be impractical to treat all the material excavated in this way, it is worth washing and hand sorting small samples in the field while the excavation is in process, to ensure that no faunal remains are overlooked. Bulk processing in the laboratory is especially productive with very rich sites containing small animals, notably those sites where non-archaeological bone from owl pellets makes up a major component of the deposit. Although not representing the remains of food animals, large samples of small marsupials and rodents are invaluable in determining the palaeoenvironments around the site.

The excavation of partially or completely associated skeletons, such as human burials, poses other problems. Various palaeontological techniques have been used in archaeological sites, among them consolidation of the bones before removal or the use of plaster jackets for transportation. Consolidation or hardening of poorly preserved specimens consists of the introduction of solutions of adhesives, in appropriate solvents, into the bone, so that when the solvent has evaporated the residual adhesive strengthens the bone and holds fragmentary pieces together. In general, consolidation of bone in the field should be carried out only when it is absolutely necessary; most archaeological bone is strong enough to be left untreated provided careful packaging is used to minimise damage during transport.

Bone that is damp and soft often hardens as it dries. Many specimens in this condition can be safely moved without chemical treatment if they are exposed to the air for several days. The excavation area should be protected from rain and wind during this time.

There are two important reasons why field treatment should be kept to an absolute minimum.

(1) In inexperienced hands the use of consolidants or plaster can have disastrous results. If large amounts of adhesives are sloshed onto bones which are coated with carbonate or encased in a block of matrix it may be

impossible later to clean them. These specimens make excellent paper-weights but are of little scientific value. Repair of bones damaged during transport (which should be minimal if they are properly packed) is often easier and less time-consuming than preparing specimens badly treated with consolidants.

(2) Any chemical treatment will preclude the use of the bone for subsequent chemical analysis, such as radiocarbon dating, amino acid racemisation dating, and 'finger-printing' of bone by its chemical constituents. These techniques are discussed further below.

The simplest method for recovering associated skeletons is to remove the bones individually without any treatment, after their relative positions have been recorded diagrammatically and photographically. The bones may be marked with pencil or ink to indicate orientation. Sections of a skeleton, or small specimens such as skulls or individual bones, can be removed in a block of matrix. At its simplest this involves no more than lifting (on a shovel) sections of a large skeleton (or the whole of an isolated bone), with surrounding matrix. The pieces lifted are placed immediately in rigid containers and the exposed surface and if necessary the sides are then covered and packed with toilet paper or tissues, followed by crumpled aluminium foil or newspaper, and loose sand. While there may be some movement of the bones during transport, their relative positions will be retained. Cleaning and removal can be carried out at leisure in the laboratory.

Small specimens, up to about 10 by 10 cm, in a reasonably solid matrix can be removed in blocks without the use of containers. The surrounding matrix is dug away on all sides, leaving the specimen standing above its surroundings on a pedestal of matrix. By gently sliding a shovel beneath the block it can be transferred to one or more sheets of heavy-duty aluminium foil and covered with loose crumpled toilet paper and sand. The whole block is then firmly wrapped in several layers of aluminium foil and plastic bags, then tightly fastened with masking tape. It is useful to mark the top of the block with a felt pen or label. Careful transport is needed to ensure that the blocks do not overturn and that nothing heavy is placed on top of them.

For larger specimens, collapsible boxes of rigid steel can be used. After the specimen has been pedestalled the sides of the box are bolted together around the remaining block. The whole structure—box, matrix and specimen—is jacked laterally onto the base of the box, which is then bolted in place. Again, the bone exposed on the surface must be protected with tissue or toilet paper, aluminium foil or newspaper, and sand. Additional packing may be needed between the sides of the block of matrix and the box to limit lateral movement. Several boxes may be necessary to remove one human skeleton in sections, and care is needed to ensure that the base plate does not damage any bone extending beneath the surface. The technique can be used safely only where the full extent of the specimen to be removed is known. Again, careful transport is required.

The ultimate technique for collecting large specimens is the standard palaeontological method of the plaster jacket. Judicious removal of the surrounding matrix leaves the specimen standing on a pedestal. The surface of the block and the specimen are covered with wet paper, and then with plaster of paris and bandages supported, if necessary, with splints. After the plaster has set the pedestal is excavated away, the block turned upside-down, and the undersurface is again covered with plaster. The whole block is then taken to the laboratory for removal of the skeleton.

It is important to stress again that most archaeological bone can be collected safely with a minimum of treatment. However, it is useful to be aware of the various methods available for special situations. An excellent handbook on palaeontological techniques is Rixon (1976), which includes a list of the different consolidants available and their properties, as well as more detailed descriptions of the standard collecting methods outlined above. Haglund (1976) gives a detailed description of the use of consolidants in the field in her account of the excavation of the Broadbeach burial ground, and Prokopec (1975) describes the methods used to consolidate and prepare the skeletons from Roonka. Macintosh (1972) describes and illustrates the simpler method of collecting skeletons without field treatment and discusses the problems that may arise through misuse of more complicated procedures.

## TREATMENT OF BONE IN THE LABORATORY

Whether it consists of bags of small fragments or partly associated skeletons, the sample of bones, when it arrives in the laboratory, is usually dirty, covered with ash or coated with calcium carbonate. In many cases a light brushing with a soft toothbrush is sufficient to prepare the bones for further study but water washing may be required. Carbonate encrustation can be removed by the technique of acid washing. The acid used for this purpose is acetic acid which attacks the carbonate in the matrix preferentially to the apatite in the bone. The bones to be washed are placed in trays or dishes and covered with the acid solution, usually diluted to somewhere between 2% and 10%. It is wise to test a small piece of bone first, especially if it appears to be fragile or poorly preserved, to make sure that it will stand up to the treatment.

The carbonate coating may dissolve of its own accord or it may need to be gently pulled off with forceps or dental probes. If there is a great deal of coating on the specimen lower concentrations of acid should be used to avoid damage to the bone from the effervescence caused by the reaction of the carbonate with the acid. After soaking in the acid solution, the bone should be washed for at least three times as long as it was in the acid, either in running water or in several changes of still water. If the carbonate coating is particularly tenacious, or the bone deteriorates after a short time in the acid it can be washed as above, thoroughly dried and then coated with a consolidant before further acid treatment.

Whether or not the bone has been washed with water or acid it may benefit from treatment with consolidants if it is fragile or if the surface is chalky or flaking. Polyvinyl acetate and polyvinyl butyral are commonly used as consolidants for bone, as described by Haglund (1976) and Prokopec (1975). Polybutylmethacrylate (Bedacryl) is also often used, especially in acid preparation. The specimens can be sprayed or painted with solutions of these consolidants, or they can be impregnated under vacuum (Rixon, 1976). Polyvinyl butyral, with ethanol as solvent can be used as a routine consolidant for bone, in conjunction with acetone-soluble adhesives for repairing bones or gluing-in teeth. A repaired specimen can then be disassembled, if necessary, by dissolving the glue in acetone, without affecting the basic consolidant.

Again, treatment with any of these chemicals can preclude the use of the bone for chemical analysis. It is best to use consolidants only on specimens such as skulls and teeth that are important for

identification purposes, and in all cases to reserve some bone completely untreated for future analysis. Acid preparation should also be used with caution. New techniques such as the study of tooth wear by electron microscope scanning cannot be applied to specimens whose surface morphology has been changed by acid etching (Walker *et al.*, 1978; Brown, 1978).

Adequate packing of bones, whether for storage or transport, is important. Bone is very fragile, even when treated with consolidants. Small bones need special care and should be stored in plastic vials; several of these can then be placed in one box. For temporary or permanent storage, boxes should always be used in preference to plastic bags, although small bone samples in small plastic bags can be safely stored within boxes. The weight of many bones in one large plastic bag, or in several plastic bags stored on top of one another, can damage them all. Avoid placing cotton wool directly against bones, especially delicate ones with fine projections. It can be difficult and tedious to remove, and may cause damage in the process. If bones are wrapped with paper tissue or toilet paper, cotton wool can be used as a 'filler', but wads of tissue, toilet paper or crumpled aluminium foil are as effective and safer. In any case, separating bones by species, or excavation level, into several small vials or boxes, using tissue or toilet paper as wrapping usually provides adequate protection.

## CHEMICAL ANALYSIS OF BONE

Bone consists of a structural framework of both inorganic and organic material plus the living cellular tissues. After death the cellular material decomposes rapidly, but the inorganic matrix, crystals of calcium phosphate with a structure of hydroxyapatite, and the organic matrix, the protein collagen, may survive for long periods. In theory, bone is an ideal medium for radiocarbon dating material in archaeological sites; unlike charcoal, which may come from wood much older than the fire that produced it, a date on human or animal bone must relate directly to the event studied—the time of death of the individual concerned. In practice, bone dating has proved to be rather unreliable because of contamination problems. Ages reported in the early years of radiocarbon dating were obtained from the total carbonate present in the sample, and many of these are now recognised as being gross underestimates of the true ages. Later refinements consisted of fractioning the bone carbon into secondary carbonate (usually contamination from soil carbonate), inorganic carbon, from the hydroxyapatite, and organic carbon from the collagen (Tamers & Pearson, 1965; Haynes, 1968).

Comparison of radiocarbon ages for different fractions of the same bone with radiocarbon ages for contemporary shell and charcoal samples has shown that apatite gives reliable results in some situations, collagen in others. This can be related in general to the depositional environment of the bones, but the correlation is not sufficiently predictable for the routine use of bone dates without comparative samples of charcoal or shell. Polach (1971, 1976) and Hope (1978) discuss the difficulties in interpreting radiocarbon dates from bone samples and give some salutary Australian examples. None the less, since the errors involved usually result in a younger than true age, bone dates can be valuable in some cases where the relative antiquity of a specimen is in question.

Errors in radiocarbon dates on bone apatite are due to the exchange of carbon between soil carbonate and the hydroxyapatite crystal. Carbon is not the only element that moves into the apatite structure over the course of time; many others present in trace amounts in the sediment around the bones, such as fluorine, iron, strontium and uranium, do likewise. This effect has been put to use in relative dating. By 'finger-printing' the bone, measuring the amount of trace elements incorporated since deposition, it is often possible to determine whether or not a specimen comes from a certain stratigraphic horizon. The best known example of the application of fluoride dating was the demonstration that the Piltdown jawbone was not contemporary with the genuinely fossil cranial fragments (Weiner, 1955). In Australia fluoride analysis has been used by Gill (1973), Gill & Sinnott (1973) and Milham & Thompson (1976) to test the validity of faunal associations. Gill (1955), and Oakley (1969) give the theoretical background of the technique, while Sinnott (1973) and Singer & Armstrong (1968) describe different methods of analysis.

An alternate application of trace element analysis is in the determination of dietary differences in past populations by, for example, comparing the amounts of strontium in their bones (Toots & Voorhies, 1965; Brown, 1974). In this case, the element measured is that which accumulated during the life of the individual whose bones are studied, and contamination by strontium in the depositional matrix of the bone can introduce errors analogous to those affecting radiocarbon dating of apatite.

Wyckoff (1972) has compiled tables of the amino acid composition of bone collagen from different kinds of animals, and has demonstrated that in some fossil bones the proportion of different amino acids is similar to that present in modern bones. This is particularly so in bones preserved in anaerobic situations, such as the La Brea tarpits in California. Other bone samples yield amino acid compositions that differ from modern collagen; this is interpreted as due either to the addition or replacement of collagen amino acids by bacterial amino acids after death, or to differential breakdown of different amino acids.

The amount of nitrogen (a measure of protein) remaining in a bone can be used as a rough indicator of relative age in much the same way as trace elements; the determination of the nitrogen content of a sample is a usual preliminary to the radiocarbon dating of the collagen, in estimating the amount of bone needed to provide adequate collagen for analysis. Future research on the rates of breakdown of different amino acids may lead to new methods of both absolute and relative dating of bones.

Another technique using the amino acids present in fossil bone is that of amino acid racemisation dating. Amino acids exhibit the property of 'handedness' or optical isomerism. Solutions of pure isomers rotate the plane of polarisation of polarised light to the right or left, depending on the handedness of the amino acid isomer. This depends on the geometry of the carbon atom, which permits the formation of molecules identical in every respect except that they are mirror images. In higher organisms all amino acids are effectively laevorotatory (L), although in laboratory synthesis both L and D (dextrorotatory) forms occur in equal amounts.

An amino acid in one form will change very slowly at ordinary temperatures to the opposite form—this is called racemisation. Consequently, the L-amino acid content of a bone will gradually change with time until a 50:50 mixture of D and L isomers is present. The rates of change of different amino acid isomers have been experimentally determined, and these can be expressed in half-lives comparable to radioactive isotope decay half-lives. Examples of half-lives are 48 000 years for isoleucine and 3500 years for aspartic acid;

carbon-14 has, for comparison, a half-life of 5500 years.

The rate of amino acid racemisation is highly dependent on temperature. Determination of the age of a bone by the amount of racemisation that has occurred requires an estimate to be made of the temperature regime that has affected the bone during the time it has been buried. The problems associated with this, and with contamination of bone during burial, are considerable, and at the present state of research amino acid racemisation dating can only be validly used as an adjunct to radiocarbon dating, and not as an absolute dating technique in its own right. Davies & Treloar's (1977) excellent critical review of racemisation dating discusses the limitations and possibilities of the method.

Though all the techniques described above need to be proven further before they can be applied routinely to bone samples they can be useful in certain specific situations. It is likely that analytical methods will improve in the future, so it is important to preserve small samples of bone from archaeological sites in their original condition.

## HUMAN REMAINS

Although the collection and treatment of human and animal bones involve the same techniques, the problems involved in their subsequent analysis differ considerably. Students of human remains deal with only one, very well known, species, at least in late Pleistocene and Holocene archaeological sites. Libraries have been written about the identification, ageing, sexing and pathologies of human skeletons. I do not intend to repeat this information here and refer those interested to the relevant literature, among which the following should be required reading for anyone planning to work in this field.

Two classic texts on human anatomy, *Gray's Anatomy* (Warwick & Williams, 1973) and *Frazer's Anatomy* (Breathnach, 1965) contain basic descriptions of the human skeleton, while Scott & Symons (1977) and Wheeler (1974) concentrate on dental anatomy. Skeletal descriptions have been written specifically for archaeologists by Brothwell (1965) and Anderson (1962).

For Australian archaeologists, the most important works describing Aboriginal skeletons, particularly with reference to determining sex from the crania and postcranial elements, are Larnach & Freedman (1964), Larnach & Macintosh (1967) and Davivongs (1963a, 1963b). Larnach & Macintosh (1966, 1970, 1971) describe non-metrical features of crania and mandibles. The contributors to Kirk & Thorne (1976) provide a résumé of physical anthropology in Australia, and together with Thorne (1977, 1980) bring together the theories of the origin of Aboriginal Australians.

## FAUNAL ANALYSIS

Students of animal bones from Australian archaeological sites face many problems in both identification and interpretation. The Australian vertebrate fauna is extensive but the taxonomy and ecology of some groups are poorly known. Further, comparative skeletal material is often hard to come by.

### Learning the fauna

The vertebrate fauna of Australia and New Guinea consists of freshwater and marine fish, amphibians, reptiles, birds, monotremes (the platypus and echidna), marsupials, rodents (both native and introduced), bats, marine mammals (seals, whales and dolphins) and an assortment of introduced placental mammals such as rabbits, sheep, cattle, dogs and cats.

Each kind of animal is referred to by its specific name, a binomial consisting of genus + species, always written in italics with the generic name capitalised, e.g., *Macropus giganteus*, the eastern grey kangaroo. Species are grouped into higher categories: genus, family, order, etc., in an hierarchical system aimed at reflecting evolutionary (phylogenetic) relationships. The categories most commonly used in compiling faunal lists are species, genus and family. Zoological family names are capitalised and consistently end in '-idae'. They are often abbreviated and used as collective terms for the relevant group of animals. For example, *Macropus giganteus* belongs, with other kangaroos and wallabies, to the family Macropodidae. Kangaroos and wallabies can be collectively termed macropodids; bandicoots, in the family Peramelidae, peramelids.

Because our understanding of the phylogenetic relationships develops as research progresses, these taxonomic categories tend to change with time. Species may be moved from one genus to another; amongst the marsupials, this has happened most often with the macropodids. Ride (1962) lists the various generic assignations used by different zoologists over the last 100 years for the species of macropodids and Kirsch (1977b) lists the alternate names used for a variety of marsupials. Species can be sunk when two populations of animals originally regarded as different are found to be the same. The different species names may then be retained as subspecific names if the two populations are distinct enough to be recognised as such. Alternately, a species may be split in two if different populations are shown to be distinct. This has happened recently with the grey kangaroos. The eastern and western forms were originally considered as subspecific populations of a single species; now they are regarded as two separate species, *Macropus giganteus* in the east and *Macropus fuliginosus* in the west. Further subdivision would be possible if the subspecies of the western grey kangaroo, *Macropus fuliginosus fuliginosus,* on Kangaroo Island, and *Macropus fuliginosus melanops,* which ranges from Western Australia to western New South Wales, were to be regarded as full species.

Family names tend to be more stable, but these may change with time also or vary from one authority to another. Marsupial families have been relatively constant though several changes recently suggested, such as the splitting of the old family Phalangeridae (the possums) into three families, Phalangeridae (brushtails and cuscuses), Burramyidae (pigmy possums) and Petauridae (ringtails and gliders) have become generally accepted. In other groups, notably the fish and molluscs, several different systems of family-level nomenclature may be in use simultaneously.

Although the system of zoological nomenclature is moving towards a generally accepted, stable classification, one needs to be aware of all the past changes because the older names are permanently embedded in the literature. It is necessary to understand the vagaries of the system in order to compare one authority with another, new results with older species lists, and to make use of distributional and ecological data.

The following books and papers form a basic reference library on the taxonomy, distribution and ecology of the Australian vertebrate fauna. Most of these include further references. Many useful reviews on both fauna and flora are contained in the three-volume publication *Ecological Biogeography of Australia* (Keast, 1981).

For mammals, Kirsch & Calaby (1977) give the most up-to-date listing of the marsupials of Australia and New Guinea. Ride (1970) includes rodents, bats, seals and monotremes as well as marsupials and contains ecological data and an extensive bibliography. Hyett & Shaw's (1980) field

guide also includes whales, dolphins and introduced mammals, and Watts & Aslin (1981) provide an excellent account of the Australian rodents. Archer (1981) reviews the origins and radiations of Australian mammals and contains further suggested changes at a subfamily level. Ziegler & Lidicker (1968) and Ziegler (1977) provide keys, species lists and ecological data about New Guinea mammals, not usually included in books dealing strictly with the Australian fauna. Stonehouse & Gilmore (1977) and Hunsaker (1977) edit two books with identical titles, *The Biology of Marsupials*, both containing a series of individual articles on marsupials. The former is of greater value to those interested in Australian species, but contributions by Kirsch (1977a, 1977b) in the latter are of interest; similarly, Tyndale-Biscoe (1973) is useful for general marsupial biology and ecology. Strahan (1980) gives a list of recommended common names for Australian mammals. Finally, the bulletins of the Australian Mammal Society over the last 20 years have included regular bibliographies on Australian mammalogy.

Many books are available on the birds of Australia; among the best as introductory handbooks and species lists are the field guides by Slater (1970, 1974), and the Readers Digest (1976). Other books on regional faunas such as Frith (1969), or on specific groups such as waterfowl (Frith 1967) also provide data on taxonomy and ecology. The CSIRO Division of Wildlife (1969) has produced an index of bird names which lists the various alternate names used in the past for different species. The species of reptiles and amphibians of Australia are well covered by Cogger (1975), frogs by Barker & Grigg (1977) and freshwater tortoises by Goode (1967). Heatwole (1976) provides an excellent introduction to reptile ecology.

Many books are also available on Australian fish. Two of the most recent are the field guides by Thompson (1977) and Carcasson (1977), which include reference to earlier works. Munro (1967), the standard work on the fish of New Guinea, is also useful for northern Australia. Lake (1971, 1978) and McDowall (1980) list the freshwater fish of Australia. As for the mammals, there are many useful articles on the ecology and taxonomy of the lower vertebrates in scientific journals; access to these can be gained through the reference lists of the above books.

## Learning the bones

Learning to identify the bones of Australian vertebrate species can only be done by practice with the help of good comparative skeletal collections. Although collections of vertebrate skeletons, especially of mammals, are maintained by most state museums and by some university departments, the range of material kept in these institutions usually reflects zoological preoccupations rather than archaeological ones.

The taxonomic descriptions of animal species on which their names are based refer mainly to key characteristics of their external appearance, and in mammals, of their teeth and skulls, with emphasis only on those characteristics which differentiate related species. Species descriptions are also usually based on complete specimens of the animals, except in the case of extinct species. So one of the basic problems of identification of bone material, particularly of modern species, lies in reconciling the zoological description with fragmentary and incomplete specimens. Since this is a problem inherent in all palaeontological work, papers dealing with species found in fossil sites, whether extinct or not, are often of greater value to archaeologists than studies of the living animals.

Identification of bone material to species may often be only tentative because the fragments found in the archaeological (or palaeontological) assemblage do not retain the key characteristics that distinguish between closely related species or genera. Complications also arise because of differences within species due to age, sex and pathology as well as geographic and individual variation.

Even without positive identification of all fragments, however, a great deal can be done with a pile of bones. The shapes, sizes and often the texture of the bones differ considerably between different groups of animals, so it is often possible to sort bone fragments into mammal, bird, fish, etc., without knowing the identity of any of the species represented. While most books on archaeological bones written elsewhere in the world are of little use in identifying Australian species (except for introduced species such as cattle, dog, etc.), several provide well illustrated introductions to vertebrate skeletal anatomy. Olsen (1964, 1968, 1971), Ryder (1968) and Schmid (1972) are valuable for their descriptions and excellent illustrations of skeletons of the different vertebrate classes, i.e., mammal, bird, reptile, fish.

Initially the bone fragments should be sorted into those recognised as identifiable at one level or another, such as mammal teeth, jaws and postcranial, or fish vertebrae, and into those less readily identifiable (often the greater amount). The identifiable bones are then sorted into distinct taxa, (i.e., macropodids, rodents, birds, reptiles, etc.) even if the species are not yet known.

Most mammals can be identified to species on teeth alone, provided that a maxillary or mandibular toothrow is available and the teeth are not too worn. The more specimens of the same species present in the site, the more certain will the identification be. Individual teeth or incomplete toothrows, which in themselves may not preserve diagnostic characters, can then be attributed more confidently to species by comparison with the larger sample. Mammalian postcranial bones are not so straightforward. It is not usual museum practice to retain the complete skeleton of all mammal specimens; usually just the skin and skull are kept. This applies mainly to larger animals; complete or partial skeletons of small species (rat-sized) are often kept. Consequently there is very little comparative material available for many medium and large marsupial species, the ones most important in archaeological sites, to give an idea of variation between species, let alone between sexes, age classes, or geographically separated populations of the same species. Certain animals, such as the spiny anteater, the thylacine and the wombats have very distinctive postcranial bones and are easy to identify. In other groups, such as the kangaroos and wallabies, variation between species is mainly in size.

To identify below the family level, start with the modern faunal records for that area. This is sometimes straightforward as in Tasmania where there are few species, and identification becomes automatic with practice. In other areas with many poorly known species (such as New Guinea) this is more difficult and it may be impossible to identify some mammals below genus. If in a well known faunal area the material does not fit with any of the modern species, then the next comparisons should be made with a nearby geographic region, in the case of Tasmania, with southern Victoria. The older the deposit, the greater the likelihood that it will contain some locally extinct species. Apart from this, complications such as individual age of specimens may make identification difficult; and in some cases identifications may only be tentative. This is usually indicated by listing the taxa as, for example, *Bettongia* sp., if it can be identified to the genus but not to any species of bettong; or *Bettongia* cf. *penicillata* if it

has characteristics that rule out say *B. lesueur* or *B. gaimardi* but does not have the key characteristics for positive identification as *B. penicillata*.

The best introduction to the skulls and teeth of Australian mammals is Merrilees & Porter (1979). Although this is regionally restricted to the southwest of Western Australia it is a useful adjunct to a comparative skeletal collection from any region in Australia. It contains photographic illustrations annotated with identification criteria, at both generic and specific level. Wood Jones (1923–25) is also useful although the taxonomy is out of date. Various papers discussing the identification of fragmentary material from fossil sites, such as Smith (1971, 1972) and others listed in the zoological works referred to earlier are also of value. However these still need to be used in conjunction with a skeletal reference collection.

In contrast to mammals, the identification of bird bones is based almost entirely on the postcranial skeleton. While some particularly specialised birds such as penguins are easy to identify, the great variety of Australian birds and the subtleness of distinction between related genera and species makes detailed identification of fragments a job for the specialist. Further there are only two extensive collections of bird skeletons in Australia, at the National Museum of Victoria and the CSIRO Wildlife Division in Canberra. Olsen (1968) includes excellent drawings of the various elements of the avian skeleton, while Scarlett (1972) provides illustrations of the bones of New Zealand bird species; many of these or their near relatives occur in Australia.

Reptile bones are identified on both dental and postcranial fragments. Since the teeth are less specialised than in mammals discrimination between species and even genera is often difficult. Olsen's (1968) illustrations of reptiles and amphibian bones are useful, although of North American species. Smith (1975, 1976) has studied the vertebrae of some Australian snakes, as well as fossil reptile bones, while Tyler (1976, 1977) illustrates the pelvic girdles of some Australian frogs.

Fish pose considerable problems with regard to bone identification. The marine fish fauna of Australia is diverse, especially in the tropical regions and fish can be a significant component in coastal archaeological sites. Unfortunately, most museums store their fish collection as whole specimens in spirit (alcohol), since the taxonomy of these animals depends almost entirely on external characters. Apart from regionally specialised and usually incomplete collections made for archaeological purposes, such as that held by the Department of Prehistory, Research School of Pacific Studies, Australian National University, the Queensland Museum is the only state institution maintaining a collection of fish skeletons. Further, while fish groups are diverse, within each group there may be little variation in the teeth or skeleton beyond size, and that may vary considerably with age within a single species. So the compilation of a reference collection of skeletons of identified fish from a specific region is usually necessary for the identification of archaeological fragments. The freshwater fish of Australia are much less diverse than the marine fish, and because of this are in some respects better known. The otoliths of these species are distinctive and have been used to identify the presence and numbers of fish species in archaeological sites (Kefous, 1977).

Casteel (1976) provides a useful introduction to the identification of fish bones and to methods of analysis of archaeological fish remains, including the estimation of live weight from vertebra and otolith lengths. Voorhies (1969) discusses methods of estimating fish size and population structure from fossil assemblages. Barnett's (1978) illustrations of the jaws of a range of fish from the Solomon Islands are of assistance in discriminating between diffferent families of tropical fish. Leach & Anderson (1979) provide some drawings of labrid skeletal morphology, applicable to Australian as well as to New Zealand taxa.

## Faunal interpretation

When the fragments of bone have been identified as accurately as is feasible—often the nature of the problem being addressed makes it unnecessary to spend a great deal of time trying to identify absolutely the total collection—there comes the problem of handling the data. At this stage, the record for each excavated level of each excavated pit consists of a list of numbers of left or right mandibles, or humeri or femora, or of vertebrae, of a wide range of different sorts of animals of different sizes, whose fragmentary skeletal remains may not be strictly comparable, i.e., fish vertebrae and mammal teeth. Quantifying this material in usuable terms involves decisions regarding the use of weights or numbers of bones, or minimum numbers of individuals.

Rather than repeat at length the alternatives available and the arguments for and against them, I refer the reader to Ziegler (1973). This paper presents a comprehensive account of methods of handling this sort of information and should be basic reading for all those involved in archaeological faunal analysis. Hope (1980) includes an annotated bibliography of papers on faunal analysis, concentrating on those which discuss interpretational problems of relevance to Australian sites. The subjects included are general taphonomy; effects of predators and scavengers; techniques (particularly those published after 1973); general archaeological faunal analysis; cremation; ethnographic studies; australopithecines; and South African and Australian sites.

Whatever methods are finally adopted for handling the data, the final problem confronting archaeologists is that of interpreting their results in an archaeologically meaningful way. Archaeologists have had a tendency to assume that all aspects of the faunal material such as species composition, fragmentation of the bones, distribution within the site, etc., are due to intentional activities of people. Faunal studies over the last 10 years have shown that great caution is needed in interpreting archaeological faunas in terms of separating cultural and natural processes. This new approach owes much to the development, within palaeontology, of taphonomy, the study of the processes of fossilisation. Some works such as Voorhies (1969) are strictly palaeontological, but are of great relevance to archaeological studies. In other cases, as exemplified by Behrensmeyer's work on the African Lake Turkana sites (Behrensmeyer, 1975; Boaz & Behrensmeyer, 1976), archaeology and palaeontology merge.

Discrimination between cultural and natural processes is always likely to be a problem in the interpretation of many aspects of archaeological sites, but the problem is greater with bone than with anything else. This is partly because bone is naturally abundant in the environment, so much so that many fossil deposits in Australia and elsewhere, both in caves and in the open, have been mined in the past for phosphate. Bone tends to accumulate in caves because animals live and die there, predators take the remains of their prey there, and caves act as natural traps. Although cave sites pose special problems, any situation with a suitable preservational environment where animals are likely to die naturally, or where their remains are likely to be aggregated by the action of predators,

must be treated cautiously. This includes lake or swamp edge environments and sand dunes, all of which are equally likely to preserve archaeological material.

The actual source of the bone can bias the faunal assemblage in many ways. The size range of the animals preserved may depend on the size of the predator or on the size of the opening of a natural trap. Species composition will vary depending on the prey preferences of the predator concerned. This is particularly significant with birds of prey, and bones derived from owl pellets can often be recognised immediately because of the preponderance of small rodents and dasyurids.

The degree of fragmentation of the bones can also be affected by their provenance. The highly fragmented nature of bone in several cave deposits in Australia has been attributed to the Tasmanian devil, *Sarcophilus harrisii* (e.g., Hope *et al.*, 1977), but some workers such as Archer (1977) and Gould (1979) have suggested chewing by humans as a cause of extreme fragmentation. Other processes are also at work in archaeological sites, such as intentional breakage of bone during butchering and cooking, and subsequent fragmentation from successive burning and treadage of bone into the deposit. It is not clear whether it will ever be possible to distinguish fragmentation from one or other of the above causes; usually several processes affect the bones in their incorporation into the sites. Hope *et al.* (1977) and Bowdler (1979) provide examples of attempts to qauntify bone fragmentation in order to discriminate between different processes.

Yellen (1977) gives an excellent critique of the sorts of assumptions made in interpreting archaeological bone. Based on his study of procurement of game and its subsequent cooking, partitioning, distribution and disposal by the !Kung Bushman, he discusses the cultural and natural variables that affect representation of bones in a site and their degree of fragmentation. He then critically reviews the assumption made in previous analyses of archaeological faunal remains.

Yellen concludes optimistically that all groups of people leave a distinctive cultural imprint on the faunal material they dispose of. This imprint results from a series of ordered rules as to how a carcass is to be treated, some of which are cultural reasons tied to the nature of the animal skeleton, others being subjective. Given enough studies of the effects of natural agencies on bone, of various butchering techniques and the analysis of small fragments from archaeological sites, this cultural imprint might be distinguished.

Many Australian archaeological sites are even more complex than the one discussed by Yellen in that the bone is of mixed provenance in the first place. Rarely can all the factors involved be determined without adequate control studies, most of which have yet to be done. At the moment the best strategy in interpreting these complex sites is to err on the side of conservatism, by attempting to explain as much as possible in terms of natural processes, so as to narrow down the possible cultural factors. Extreme cultural explanations should be considered only in default of all other alternatives.

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# Chapter 13

# Sieving seashells: midden analysis in Australian archaeology

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> *midden,* dunghill; *kitchen midden,* prehistoric refuse-heap, chiefly of shells and bones. (*Concise Oxford Dictionary.*)

This chapter is not in fact about the analysis of dunghills; rather it is about the analysis of what the *Concise Oxford Dictionary* calls 'kitchen middens'. This is not a term commonly used in Australian archaeology, where 'shell midden' (e.g., Ambrose, 1967) or simply 'midden' (e.g., Lampert, 1966: 83) are the terms preferred for the phenomena to be discussed here. These phenomena are archaeological sites of two sorts. The first is a deposit containing shells occurring somewhere in the open, near a beach or estuary or rocky shoreline, or an inland lake or river. The second is a deposit containing shells occurring within a cave or rockshelter, but also usually near one of the aquatic molluscan habitats mentioned. These sites differ from other Australian prehistoric sites in that the deposit will consist of 50% by weight or more of a class of faunal remains: the shells of marine or freshwater molluscs. Middens therefore present both an advantage, and a problem. The advantage is that such sites preserve an abundance of dietary remains, which have the potential to tell us a great deal. The problem is that these remains are so very abundant; in most cases, it is simply not logistically feasible to keep all the shells one excavates. We are accordingly faced with a *sampling problem.*

The main thrust of this chapter is to describe the usual techniques of, firstly, acquiring adequate samples from middens in the field, and secondly, analysing these samples in the laboratory. On the whole, simple methodologies only are described; more complex procedures are alluded to but not discussed in detail. Before discussing actual analytical procedures a brief review of the relevant Australian literature is presented, from which subsequent examples are drawn. A brief discussion of the interpretation of the results is deferred to the end of the chapter.

## AUSTRALIAN MIDDEN ANALYSIS

Surprisingly few midden analyses of any sophistication have been carried out in Australia, although this might be seen as one of the consequences of prehistoric archaeology being of such recent vintage here as an established discipline. Ambrose, writing in 1967, could list only four published Australian examples: Jones (1966), Lampert (1966), McBryde (1965) and Megaw (1966). Nine years later I could add only seven further examples: Wade (1967), Megaw *et al.* (1974), Haglund-Calley & Quinell (1973), Campbell (1972), Coutts (1970), Lampert (1971), and Bailey (1975), all cited in Bowdler (1976), which might be added to the list along with Bowdler (1971). In the last three years only Bailey (1977) has published any sort of account of a midden analysis.

Other accounts are to be found in theses, which are either entirely unpublished or which have been published in summary form only. Examples at the honours level are those of Coleman (1966), Bowdler (1970), Barz (1977), and Gaffney (1978); Lourandos (1970) offered his thesis for a master's degree, and there are several doctoral theses containing midden analyses such as White (1967), Jones (1971) and Bowdler (1979). It is in a sense unfortunate that it is only within these generally unpublished sources that detailed methodologies are described. Since it is these methodologies with which we are concerned it is from these sources that examples will be drawn. Of the published accounts only Lampert (1966, 1971), Coutts (1970) and Bailey (1975, 1977) offer any comparable degree of detail.

Some quite serious biases are apparent in the literature mentioned so far. Perhaps most serious is the fact that all these studies pertain to coastal environments. No detailed studies of inland shell middens are available, although such sites are common in some areas, such as western New South Wales. The only analyses of such sites are to be found in Allen's (1972) PhD thesis. One aspect of these sites, namely, the presence in them of otoliths of freshwater fish, has been studied by Kefous (1977). My chapter is for this reason, and also because of my own inexperience in such sites, largely restricted to the analysis of coastal midden sites; the general principles discussed ought however to be applicable to inland middens. Some comments on crustacean remains in inland middens have kindly been contributed by Keryn Kefous.

Within the general coastal habitat attention has been more or less equally focussed on estuarine and rocky shore middens. Most neglected are open sandy beach middens, but these seem to be rarer, smaller and generally resulting from more ephemeral occupation. Examples of these are discussed by Haglund-Calley & Quinell (1973) and Coutts (1970). A further bias is evident in the regional distribution of the studies mentioned: most have been carried out on sites in New South Wales and several on sites in Tasmania. Coleman (1966), Jones (1966), Lourandos (1970), Jones (1971), Gaffney (1978) and Bowdler (1979) have written about Tasmania, White (1967) about Arnhem Land, Coutts (1970) about Wilson's Promontory in Victoria, Haglund-Calley & Quinell (1973) and Bailey (1977) about Queensland sites; the rest are studies of New South Wales middens. (Jervis Bay is properly part of Australian Capital Territory but is referred to here as being part of New South Wales to avoid confusion.) No shell midden studies are available from Western Australia or South Australia, although Luebbers has analysed middens in the latter state for his doctoral thesis, but this was not, at the time of writing (1979), available. Shell middens as such are apparently absent from the south-western Western Australian coastline, where most archaeological work has so far been carried out in that state (e.g., Hallam, 1977). How fortuitous this regional bias is generally, that is, how far it reflects the distribution of middens in Australia or

the distribution of archaeologists, cannot be simply answered; more surveys of the sort described by Sullivan (1976) are clearly needed for more areas of the continent. Such preliminary accounts as those of Lourandos (1976) and Lorblanchet & Jones (1976) suggest that many parts of the Australian coastline are as abundant in interesting midden sites as New South Wales and Tasmania.

The dozen or so studies which provide methodological detail do in fact cover a variety of environments, and exemplify all combinations of open sites and shelter sites, and estuarine and rocky shore shellfish habitats. Coleman (1966) presents a study of small samples from the West Point site, a large open shell midden on the west coast of Tasmania excavated by Rhys Jones, while Lampert (1966) presents a study of a small rockshelter containing shell midden deposit at Durras North, on the south coast of New South Wales. White (1967) contains analyses of midden material from three caves on the estuarine plain of the East Alligator River near Oenpelli in western Arnhem Land. Lourandos (1970) contains an analysis of Little Swanport, an open estuarine site in eastern Tasmania; Bowdler (1970) presents an analysis of an open rocky shore site, Bass Point, on the New South Wales south coast; Coutts (1970) describes mainly analyses of open sandy beach/rocky shore sites on Wilson's Promontory, Victoria. (In this situation it appears that minor landform changes through time led to changes in shellfish habitats and consequently the species exploited (Coutts, 1970: 90).) Lampert's (1971) later study is concerned with four estuarine rockshelters on the south coast of New South Wales, one at Burrill Lake and three at Currarong, although the Currarong shelters are also close to a rocky shore environment. Jones (1971) presents an analysis of midden samples from the enclosed cave at Rocky Cape South which is near a rocky shore habitat in north-west Tasmania. Bailey (1975) first described an analysis of an open estuarine midden at Ballina on the north coast of New South Wales, and later (1977) investigated one of the large shell mounds near Weipa in Cape York, an extreme example of the open estuarine midden. Barz (1977) analysed an open estuarine midden on the south coast of New South Wales (technically ACT) at St George's Basin, and a similar site, the Jordan River midden in south-eastern Tasmania, was studied by Gaffney (1978). Bowdler (1979) presents data from two more Tasmanian sites, Cave Bay Cave and Muttonbird Midden, a cave site and an open site respectively, both adjacent to rocky shore environments on Hunter Island off the north-west tip of Tasmania. These studies are summarised in Table 1.

One of the earliest studies, that of Coleman (1966), is also one of the most methodologically explicit. Each procedural step is discussed in terms of both earlier research and also the particular local conditions and ultimate aim of the study. The earlier research cited is primarily the large literature pertaining to American midden analysis, especially that carried out in California. This constitutes a quite voluminous body, which has been summarised by Heizer (1960) and to a certain extent by Ambrose (1967); it will not be reviewed here. Some points however are worth making. The history of midden analysis in America stretches back at least seventy years (Uhle, 1907; Nelson, 1909, 1910; Gifford, 1916), and its aims have varied considerably over that period. There has, however, been a consistent concern to establish empirically the parameters of the assumptions made, especially those concerned with accuracy of sampling procedures. To this end, for instance, Treganza & Cook (1948) excavated a complete midden mound to directly quantify the error limits of small samples. It is this empirical basis which Coleman has drawn on, as have others such as White (1967: 21), and Barz (1977: 12ff and *passim*). It seems not unfair to suggest that the main line of Australian midden analysis derives largely from this body of work. It also seems not unfair to say that a comparable British tradition of midden analysis is largely non-existent despite the existence of shell middens, from the Mesolithic period particularly. The excavation of such sites has until recently largely proceeded as though they were not particularly different from any other sort of site (e.g., Churchill, 1965). There is of course an earlier and stronger tradition of Scandinavian midden analysis (e.g., Clark, 1975).

*Table 1*

**SUMMARY OF AUSTRALIAN MIDDEN STUDIES PROVIDING METHODOLOGICAL DETAIL**

| *Location* | *State* | *Open/shelter* | *Rocky shore/ estuarine* | *Reference* |
|---|---|---|---|---|
| West Point | Tas. | open | rocky shore | Coleman, 1966 |
| Durras North | NSW | shelter | rocky shore | Lampert, 1967 |
| Nawamoyn | NT | shelter | estuarine | White, 1967 |
| Malangangerr | NT | shelter | estuarine | White, 1967 |
| Padipadiy | NT | shelter | estuarine | White, 1967 |
| Little Swanport | Tas. | open | estuarine | Lourandos, 1970 |
| Bass Point | NSW | open | rocky shore | Bowdler, 1970 |
| Wilson's Promontory | Vic. | open | sandy beach/ rocky shore | Coutts, 1970 |
| Burrill Lake | NSW | shelter | estuarine | Lampert, 1971 |
| Currarong 1, 2, 3 | NSW | shelter | estuarine | Lampert, 1971 |
| Rocky Cape South | Tas. | shelter | rocky shore | Jones, 1971 |
| Ballina | NSW | open | estuarine | Bailey, 1975 |
| Weipa | Qld | open | estuarine | Bailey, 1977 |
| St George's Basin | NSW (really ACT) | open | estuarine | Barz, 1977 |
| Jordan River Midden | Tas. | open | estuarine | Gaffney, 1978 |
| Cave Bay Cave | Tas. | shelter | rocky shore | Bowdler, 1979 |
| Muttonbird Midden | Tas. | open | rocky shore | Bowdler, 1979 |

## THE CREATION OF MIDDENS

An important contribution to the study of coastal shell middens has been made by Meehan (1975, 1977a, 1977b) through her ethnographic studies of contemporary Aboriginal hunter-gatherers. She spent one year with the Anbarra people who live on the northern Arnhem Land coast and lead a largely traditional lifestyle. Her aim was to make a 'year long quantitative record of the total diet of a group of coastal hunters and gatherers' (Meehan, 1977b: 493). This work provides unique insights into all aspects of shellfish gathering and the creation of shell middens in this region. Many of her salient points are perhaps more pertinent to the interpretation of midden data than to its recovery and analysis, but this work should be considered as mandatory reading before such excavation is undertaken.

## THE IDENTIFICATION OF MIDDENS

The problem of not confusing natural shell beds with shell middens has been with us for some time, and distinguishing criteria likewise have been known for some time. Some new problems however have been recently brought to light which constitute other traps for the unwary. These are the possibility of a midden being of non-human origin, and that of a human midden having been disturbed by natural forces.

Criteria for distinguishing shell middens from shell beds have been advanced by Gill (1951) and Coutts (1966), and these have been summarised by Hughes & Sullivan (1974) as follows.

(1) Middens contain charcoal, burnt wood, blackened shells, artefacts and hearth stones; these are absent from marine shell beds.

(2) Middens are unstratified or roughly stratified; shell beds are generally well stratified and show sedimentary features of water laid deposits.

(3) Middens contain shells of edible species and sizes; shell beds contain shells of varied species and sizes, both edible and non-edible.

(4) Middens do not contain shell worn due to transport in the offshore or beach zone; marine shell beds often do contain such shell.

(5) Middens contain the bones of mammals used for food; shell beds do not.

(6) Middens do not contain forms of marine life not used by Aborigines, such as corals and tube worms; marine shell beds do.

Two recent sets of observations derive from small islands on either side of Bass Strait. Horton (1978) visited a fur seal colony on Seal Rocks, near Phillip Island, Victoria, and observed that the colony was littered with debris recalling a midden: seal bones, fish bones, even swallowed sandstone pebbles, corroded by seal stomach acids into unusual shapes recalling human activity; various nearby nesting seabirds had contributed to the debris. Horton also quotes the earlier observations of Teichert & Serventy (1947) to the effect that Pacific gulls drop quite large shellfish onto rocks to break them, and often do so repeatedly in the same locality, forming gull 'middens' (their word). Such a 'gull midden' is described by Jones & Allen (1978) from Steep Heads Island in the Hunter Group in north-west Tasmania. It will be seen that such seabird or fur seal 'middens' may in fact conform to criteria 2–6 for human middens. Criteria 1 however should provide a clue; clearly, seal/bird middens are unlikely to contain charcoal and artefacts, as Horton, and Jones & Allen indeed point out. It is true, however, that small human middens may not contain these either; in this case, clearly, the burden of proof is at least positive, and the presence of charcoal and artefacts should be a sufficient guarantee of anthropogenesis. Horton additionally warns however that 'bone accumulation is likely to continue even in the absence of humans'. These specific problems only arise of course where fur seals or Pacific gulls might be reasonably expected to have been, but other species no doubt can create similar misleading situations.

Having confidently ascribed a midden to a human origin by the presence within it of artefacts, charcoal and so on, it should be determined whether the midden has been at all re-worked, particularly if it is located close to a shoreline. Hughes & Sullivan (1974) suggest that many apparently undisturbed middens have in fact been re-worked and re-deposited by storm waves or fluctuating lake levels. They offer the following inclusions as demonstrating this:

(1) shells of species and sizes not thought to have been eaten by Aborigines,

(2) marine shell grit,

(3) water-worn shells,

(4) rounded pebbles,

(5) pumice.

## FIELD PROCEDURES

This chapter is not a treatise on excavation techniques but some consideration of these is important. Insofar as shell middens can be considered as special kinds of site some tailoring of normal field techniques ought to be considered. Some middens are the largest prehistoric sites with spatially continuous archaeological deposit in Australia, and this fact alone poses special problems. The shell mounds at Weipa are particularly large; they were first investigated by Wright in 1963 with the help of a bulldozer (Wright, 1971), and subsequently Bailey (1977) excavated a single square metre of one of them. Some intermediate strategy might be seen to be called for in such cases.

This immediately raises the nature of the problem: what scale of excavation is desirable? As in other situations, the answer must depend on the nature of the site, and the nature of the problem being investigated. To simply establish the chronological parameters of a site requires only a small cutting to obtain controlled charcoal samples. To answer questions about diet and economy, nature of occupation, seasonality and so on, requires a more rigorous and extensive sampling strategy. Homogeneity of content and structure can only be assumed, as ascertaining whether a site is homogeneous or not would require as much excavation as if one were assuming it to be not homogeneous. To excavate an entire site, as did Treganza & Cook in 1948, and Ranson (1978 and personal communication) more recently, is often precluded by lack of time, finances, or by the sheer size of the site. There are of course reasons which may be advanced for not excavating a complete site, in that a non-renewable resource is thus destroyed and made inaccessible to future, improved techniques.

Two approaches to a large open site are possible. One is a large continuous cutting or trench which exposes the maximum possible horizontal stretch of stratigraphy across the maximum amount of the site possible. This approach was employed by Jones at West Point (Jones, 1967; Coleman, 1966). The other is a series of discrete cuttings, which reveal the stratigraphy of the site over a comparable area, but not continuously. This was the approach I used at Bass Point (Bowdler, 1970) where my resources were considerably more limited than those of Jones. This latter technique was also used by Lourandos (1970) for Little Swanport. The extent and location of one's excavations within the site constitute a familiar archaeological sampling problem, but are only the first of many such decisions which need to be made in excavating shell middens.

The fundamental problem is, how to obtain an acceptable sample of objects (shells) which constitute a major part of the deposit. There are two reasons why this is a problem. The first is, again, the question of homogeneity. Unless the site is assumed to be, or can in some way be demonstrated to be, homogeneous, as many samples as there are heterogeneities need to be obtained. Secondly, the other kinds of objects usually sought (stone artefacts, animal bones) occur in less abundance; if large areas are excavated to obtain large samples of these, to retain all the shell from such areas would usually be logistically impossible. This means one must choose how much to discard.

Moving from one extreme to the other, the choices are as follows. In the course of excavation, *everything* is retained, *unsieved*. That is, all the deposit is taken home; this is rarely done. The next possibility is that the deposit is sieved and everything retained by the sieve or sieves is taken home. This is often done in sites where the density of shell is not high; it does, however, require the selection of some small samples if unsieved deposit is to be examined at all. Where the density of shell is high and the scale of the excavation at all large, then only selected classes of objects will be retained from the sieves, and the remainder, usually shells, will be represented only in small samples, either unsieved, or a combination of sieved and unsieved. The other extreme of course is where these objects are not sampled at all; only in certain very special circumstances, such as rescue operations, can this be envisaged as being in any way justified.

When small samples are collected it is desirable that as many as possible be unsieved. These are *solid samples*, as against small samples which are retained after sieving, which are often referred to as *shell samples*. Solid samples allow a close inspection of the composition of the deposit, in terms of the relative importance of constituents (or components), and also provide a useful specimen of deposit suitable for various sorts of soil tests and chemical tests, potential material for flotation of plant remains, and sources for pollen analysis.

The next decision, therefore, is how best to obtain the small samples. In general, one may outline three approaches. One commonly used in Australia is the *column sample*. This is a small column of deposit removed from the side or sides of a trench after excavation in vertical samples which conform to the stratigraphy as established by the larger excavation, and/or the spits removed in the course of the larger excavation. This technique was used by Lampert (1966) at Durras North and myself at Bass Point (Bowdler, 1970). The same principle, but in negative, as it were, was used by Gaffney (1978) at the Jordan River Midden: a pedestal of deposit was left in the corner of the larger excavation and removed later as a series of small samples.

Another technique involves acquiring small samples in the course of the excavation. This may be done with varying degrees of randomness. The excavator may assess the deposit in terms of its 'typicalness' and direct small samples to be bagged up accordingly. This is done so as to acquire at least one small sample per excavated unit. Some sort of pattern might be established, on the other hand, whereby every first (or fourth or fifteenth, etc.) bucketful might provide a small sample. Or a given area of the excavation might be bagged up as a small sample within every excavated unit: 20 cm × 20 cm in the north-west corner for instance; this is the same principle as Gaffney's pedestal only it is removed as the larger excavation proceeds, not afterwards. Alternatively, genuine randomness in the mathematical sense might be applied by using random number tables or dice or some such device.

Similar to the column sample approach is one where small samples are acquired from the sections after the larger excavation is completed. This involves subjective assessment by the excavator as to where the small samples will be taken. It will be seen that there are many permutations and that many techniques are variants of others. The column sample approach for instance involves a subjective assessment of where the column will be located, but involves no further subjective selection. These different mechanical operations involve three different theoretical approaches: fixed-in-space samples, where an initial subjective decision is made but there is no further decision by the excavator; subjectively 'random' samples, embodying what the excavator considers to be typical; and mathematically random selections. For this last, Barz (1977: 38) comments that 'the virtue of mathematical randomness is already lost when the fundamental prerequisite of homogeneity of the sampled universe is ignored'. A combination of the previous two approaches is probably to be preferred in most Australian situations; I found it productive for Cave Bay Cave (Bowdler, 1979: 192–93). It is safest to start with the assumption that the site is *not* homogeneous but that it will contain some regularities which will be detected during excavation, and which will serve to make a sampling strategy feasible.

While not wishing to be overly prescriptive, since each site has its own special problems, the following guidelines may be found to be of use.

(1) For a large open midden site as much of its area should be excavated as possible. Ideally, excavation of the entire site will fulfil this, but there are arguments against such a procedure, particularly for the not very experienced researcher. Limited resources usually determine the scale of one's excavation also. Where possible, long continuous trenches sectioning as much of the site as possible are desirable; otherwise a discrete series of cuttings which cover the same area discontinuously may be made.

(2) Where all the shell (or other small abundant remains) is not retained during excavation small samples need to be acquired. These may be solid samples, which are unsieved, or shell samples, which have been sieved in the field.

(3) It is best to have two sets of small samples, one set being acquired during excavation, the other set being obtained after any cutting is completed.

(4) In the first instance a small sample should be retained of each excavated unit (spit or layer); this might be done 'subjectively randomly', i.e., based on no particular criteria, or on the basis of some routine, e.g., every fifth bucketful from the same horizontal position within the square, or because of its 'typicalness'. If there is any marked horizontal variation within units then more than one sample should be acquired.

(5) Similarly with samples obtained after excavation, some may be 'random subjective': simply extracted from the sections where the excavator thinks they look typical or illustrate particular non-typical. features; or they can be more systematically acquired. The most convenient way of doing this is by column sampling. Where a trench of some size has been excavated column samples should be obtained from regularly spaced intervals along it. Where discrete trenches have been excavated at least one column per trench is in order. Again, there are situations of overlap between the two approaches; Lampert (1971: 59) used the column sample method at Currarong with individual check samples taken from other sections within the same cutting.

It is impossible to give a precise answer to the question, 'How many samples should be obtained?'. Following the above guidelines, however, should ensure that sufficient numbers of small samples are acquired. The problem of how many are solid (unsieved) samples, and how many are shell (sieved) samples is less straightforward.

The logistics of the particular site will ultimately dictate the answer; ideally, all small samples should be unsieved. This brings up two further problems.

(1) How big should the samples be?

(2) What size of mesh should shell samples be sieved through?

Treganza & Cook (1948: 292–3), on the basis of their exercise involving the excavation of a complete Californian midden, suggested that small samples of 1–5 pounds weight (*c*.500–2250 g) should be suitable for components which occur in large quantity and in a reasonably fine state of subdivision. Greenwood (1961), also analysing a Californian midden, found little variation between samples of 1110 g weight (representing total shell per level) and samples of 500 g. Barz (1977), on the other hand, found agreement between figures representing the total shell component per level and those representing half the shell component per level, but that these were at odds with 500 g samples. She argues that this is not necessarily a function of absolute sample size but of the proportion which the sample represents of the analytical unit, and that increasing this proportion should increase the accuracy of the sample.

In the field it is usually more convenient to estimate volumes rather than weights, particularly with column samples. I have found in practice that a sample of about 2000 $cm^3$ weighs about 2000 g, and that this is a convenient size which satisfies most empirical and theoretical requirements for accuracy. Barz (1977: 38) found a column sample measuring 25 cm × 25 cm × 10 cm (6250 $cm^3$) more than adequate, but one measuring 10 cm × 10 cm × 5 cm (500 $cm^3$) totally inadequate.

The question of sieve size is discussed in more detail in connection with laboratory procedures but if shell samples are to be collected it needs to be considered before fieldwork is begun. There is always the possibility that fieldwork circumstances may alter pre-arranged plans and one will be forced to obtain shell samples when this has not been anticipated. In that case the size of mesh used will simply be that used for the larger excavation, and may not be entirely compatible with later laboratory analyses. The best rule of thumb is probably to use the finest mesh available. Most Australian archaeologists use garden sieves in the field, which are not highly accurate and come in rather unwieldy imperial measurements: 1/4 inch, 3/16 inch, 1/8 inch, 1/16 inch and flywire. Most commonly used is 3/16 inch, which is about 5 mm; this is really the largest mesh which should be used for small samples. A mesh of 2 mm is probably best; the closest approximation is 1/16 inch, about 1.5 mm.

Perhaps the most important aspect of field procedure is simply to have a clear idea of what one is doing it for. No amount of fancy methodology is going to compensate for lack of thought, and one may arrive back in the laboratory with a pantechnicon of small samples and no clear purpose in mind. There is nothing surer than that if a hypothesis subsequently presents itself the samples will not be adequate to answer it. Finally, I would like to quote Barz (1977: 57) who suggests there has been a 'gross overreliance' on some of the techniques apparently suggested by Treganza & Cook: 'they nowhere justify the grabbing of a stray bucketful of matrix and calling it a "small sample"'.

## LABORATORY PROCEDURES

The following procedures for the analysis of small samples is one which has been found to be particularly useful, and has been primarily evolved by Tasmanian researchers (Coleman, 1966; Lourandos, 1970; Jones, 1971; Bowdler, 1979). It has the advantage of flexibility in that, although it is set out here as for solid samples, the overall system can be tapped into at any point, and it provides for shell samples in its later stages. It also takes into account the need for yet smaller samples for different kinds of analysis, and the fact that some samples might need to serve several different purposes. It is a technique which has enabled comparisons to be made between Tasmanian sites, with some success.

The major problem with all small sample analysis resides in the matter of choice of mesh sizes through which the samples are to be sieved. I have elsewhere (Bowdler, 1979: 193) entered a plea for standardisation of this important matter. Coleman (1966: 19), acting on the precepts of the California school, used a nest of sieves of mesh sizes 12, 6, 3 and 1 mm. Lampert in 1966 (1966: 87) used a 3/16 inch (5 mm) sieve as did Bowdler (1970: 96), but in 1971 he used a 1/8 inch (3 mm) sieve (1971: 11). White (1967: 22) used 1/4 inch (6 mm). Lourandos at Little Swanport used a nest of sieves of mesh sizes 8, 5 and 3 mm (1970: 35); Barz used sizes 9, 5 and 2 mm (1977: 39); Gaffney more or less conformed with Coleman, with sizes 12.5, 6.3, 3, 1 and 0.03 mm (1978: 47). For the Hunter Island sites I used two sets of sieves. One was primarily for shell analysis, hence sizes 12, 6, 3 and 1 mm were used to conform with Coleman for comparative purposes. The other set was used for a primarily sedimentary analysis and, in conformity with Folk (1968), the mesh sizes were 2, 4, 8, 16 mm, and so on, representing $-1\ \phi$, $-2\ \phi$, $-3\ \phi$, $-4\ \phi$. Since sets of sieves in the $\phi$ scale are readily available, compatible with standardised sediment analyses, and are on a logarithmic scale which seems to reflect many kinds of natural scaling, perhaps this is the most convenient set of sizes.

### Mechanical sorting

If samples are too large they should only be split with a mechanical sample splitter, which ensures that artificial sorting does not take place. Before proceeding, any subsamples should be extracted, for oven-drying, for instance, or for inspection for pollen. The colour of the deposit should be checked against a Munsell chart. Tests for pH might be carried out, but these are better done in the field before the sediments are bagged up. Bulk sediment samples which have been sealed for some time may produce bacterial and/or chemical activities which could alter the original pH values. Sediments are not necessarily inert (Marjorie Sullivan, personal communication; Barz, 1977: appendix IV; Bowdler, 1979: 83).

The sample to be tested is weighed, then air dried in a drying cabinet for 18–24 hours at about 40°C. The main reason for this is to ensure that comparisons based on weight are not biased by variations in moisture content between samples. It also makes the samples considerably easier to process, and the results are often of interest (Coleman, 1966: 18; Bowdler, 1979: 194). After drying, the sample is again weighed and the Munsell colour checked again.

Initially, the sample should be passed through the larger sieve sizes (say, 2 mm and over) by hand, as use of a mechanical sieve shaker may be damaging to shells, bones, small artefacts, etc. The remaining sample can now be passed through the nest of sieves chosen. Ideally, this should be done by using Endicott sieves or similar and placing them in a mechanical sieve shaker for a consistent length of time and rapidity. The material retained by each mesh and the residue are then weighed, and the weights computed as percentages of the whole.

### Sample components

After drying and mechanical sorting the next step is to sort the samples by hand into

their components: shell, stone, bone, charcoal, etc. This should be done within the size ranges established by sieving, but a convenient 'cutoff' size needs to be established. Coleman (1966), again drawing on parameters established by the California school, makes the following comments.

> 3 mm is normally selected as the critical screen size for mechanical sorting. Material smaller than 3 mm cannot be mechanically subdivided without the aid of a microscope, an operation which would preclude the use of sufficiently large samples. It is therefore impossible to determine by purely mechanical means the absolute total of any component in a sample. It is convenient to draw the line at some standard. (Coleman, 1966: 19; references omitted).

Lourandos (1970: 35, 36) used 8 mm as a cutoff, both for identifying components, and also for shellfish analysis, whereas Jones (1971: 570, 576) used 5 mm as a cutoff for identification of components but 10 mm as the cutoff for shellfish analysis. For component analysis it is best that all material over 3 mm is sorted, as Coleman indicates; using the $\phi$ series of sieves it is, in fact, possible to subdivide all material over 2 mm ($-1\ \phi$: the gravels). If there are large amounts of material between 6 mm and 3 mm, on the one hand, or between 4 mm and 2 mm, on the other, subsamples may be processed. This simply entails taking a small amount of the relevant material, weighing it, sorting it, weighing the resulting components, and calculating the percentages of these. The overall numerical relationship of the subsample to the overall sample can be easily calculated. Such a procedure can be justified on the grounds that the smaller and more finely divided the component, the smaller the sample needed to assess its relative abundance.

The residue of deposit smaller than 3 mm, or 2 mm, as the case may be, can be stored after weighing, or subjected to further analysis. It can be inspected microscopically, tested for organic carbon by loss-on-ignition, tested for calcium carbonate by chemical means (e.g., Bauer *et al.* 1972; Cook & Heizer, 1965), tested for phosphate and so on. It can be further mechanically sorted to ascertain the proportions of silts and sands present or subjected to hydrometer or pipette analysis if a large number of fines (silts and clays) appear to be present (see Folk, 1968; also Bowdler, 1979).

This mechanical and hand sorting into particle sizes and components fulfils several functions. It is informative as to the degree of sorting of large particles (technically gravels), and the exact composition of them. It may serve to define living floors, with a lower percentage of gravels, as against refuse dumps, with a large percentage of gravels (e.g., Jones 1971: 564–90). It is a useful check on field recovery rates and enables comparison of the different sieve mesh sizes as to their efficacy in recovering different components. It also enables the recovery of small components usually overlooked or otherwise discarded in the field.

## Shellfish analysis

After separating all components above a certain mesh size, say, 3 mm or 2 mm, the usual procedure is to take the shell component above this size and sort the whole lot into species, as far as practicable, weigh the resulting species (or other taxa) groups, and calculate percentages. Minimum numbers of individuals within taxa may also be calculated in the usual way (by counting parts of the shell which are identifiable, representative of a single individual and most commonly occurring), but this is not always done. It seems to me that if only one of these procedures is to be carried out it should be the latter, not the former.

The main justification for using the 'weight method' and not the 'individual method' (as they are termed by Coleman, 1966: 57) seems to be that minimum numbers disguise the significant differences of size of species, and of individuals. For instance, one abalone is considerably larger than one mussel, and this fact will be reflected in the weight of the relevant fragments but not in the minimum number estimates. On the other hand, people are not fazed by this fact when dealing with other faunal remains, such as bones; even though kangaroos are considerably larger than rats, minimum number estimates are felt to be the most appropriate mode of analysis. Size differences between species can be allowed for in subsequent calculations. Shellfish, however, may vary considerably in size within species, so it is obviously useful to provide measurements of some sort.

Coleman (1966) made a detailed comparison of the two techniques, and stated:

> It is evident that both percentages by weight and number are needed to adequately describe the proportions of shellfish species in a site, where there are few large and many small shellfish (Coleman, 1966: 37).

On the basis of comparative experiments involving live shellfish samples, however, she concluded that:

> the weight method is . . . a large underestimate of the actual meat represented by the samples . . . the individual method is a much truer estimate of the meat (Coleman, 1966: 57).

If information about diet is sought then clearly the method which is more informative about meat yield is to be preferred.

Bailey (1975: 51) offers the most bizarre reason for preferring the weight method. He rejects the use of minimum number estimates on the grounds that the site on which he worked (at Ballina, New South Wales) contained predominantly oysters, and that it contained many 'empty' shells and stunted and juvenile specimens, all of which *he could identify*. A little thought should suggest that, this being the case, counting minimum numbers of individuals will produce more accurate results than working only from weight estimates.

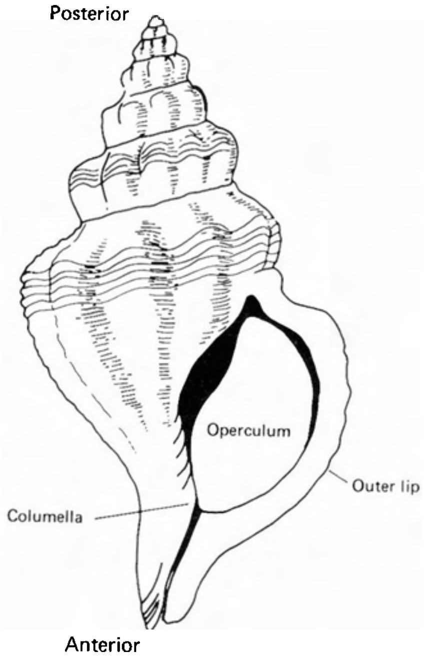
I suggest that, if time is at a premium, minimum numbers only are estimated, and that the weight method might be used in addition, if time is available. The weight method, where *all* one's material (over a certain size) is sorted into groups, is prodigal of time and effort yet provides less accurate information than the individual method. For estimating minimum numbers the shell component only needs to be sorted into species on the basis of easily recognisable parts of the shell which are potentially useful for the minimum number estimates. Parts of the shell which are not unique to the individual are ignored, that is, small fragments which might be recognisable but are of no use for estimating the minimum numbers. The saving in time to the researcher should be obvious.

## Identification of shellfish

It would be inappropriate here to attempt to provide an extensive guide to the identification of shellfish species found in archaeological sites. The researcher should provide herself with some appropriate work; there are many such available, although some are more useful than others and some regions are better provided for than others. McMichael (1960) provides an Australia-wide coverage of commonly occurring molluscs; Dakin, Bennett & Pope (1952 and later editions) are informative about many aspects of the New South Wales littoral, including shellfish; Macpherson & Gabriel (1962) are indispensable for Victoria, and applicable to Tasmania also; Cotton (1957) is useful for South Australia; and so on.

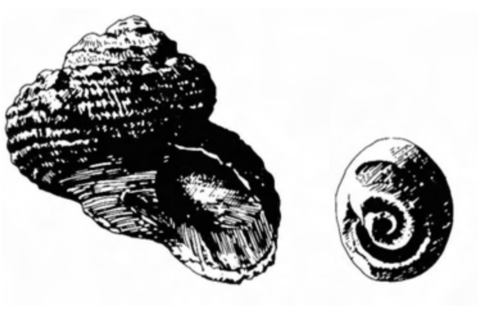
In general, however, the following comments may be found useful. Gastropods, molluscs with a single shell and a 'stomach-foot', are best identified by their posteriors, or 'tops'; anteriors, or 'bottoms'; or columellas, the central axis forming the inner lip of the mouth opening at the anterior end of the shell (Fig. 1a; see also Macpherson & Gabriel, 1962: 26, 27).

*Fig. 1a*
*Parts of a gastropod shell.*




Some gastropods, notably the turban (*Ninella torquata*) of New South Wales and the warrener, or lightning turban (*Subninella undulata*) of New South Wales, Victoria and Tasmania, have a characteristic exceptionally useful to the archaeologist. This is the operculum (pl. operculi): a

*Fig. 1b*
*Turban shell (Ninella torquata) and operculum (based on Macpherson & Gabriel, 1962).*



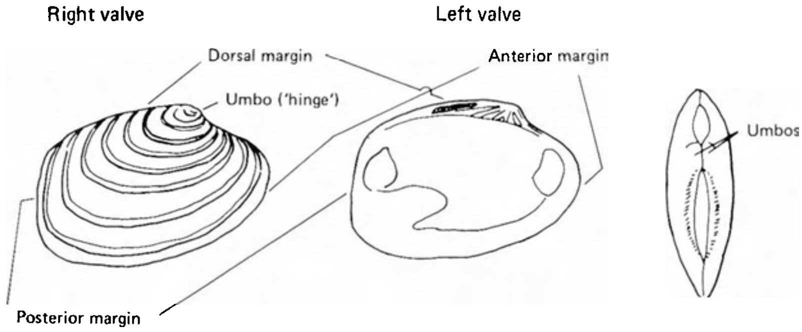
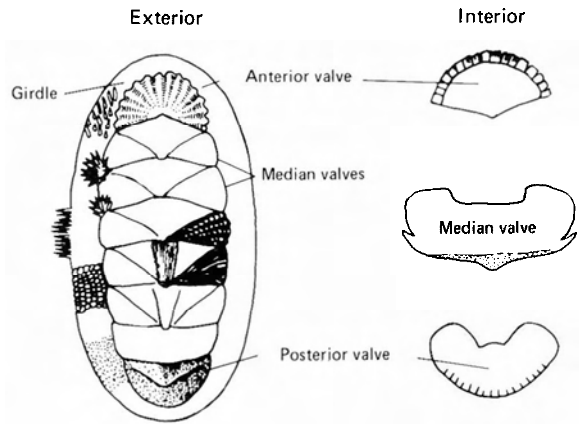



*Fig. 1c*
*Parts of a bivalve shell.*

calcareous plug attached to the posterior dorsal surface of the animal's body; it is quite separate (in life and death) from the rest of the shell, and singularly diagnostic (Fig. 1b). Some gastropods have a horny, rather than calcareous, operculum, which may or may not survive archaeologically.

Bivalves (Pelecypoda), animals with two separate, often symmetrical, shells are best identified by pieces with the hinge or umbo intact. These can usually be identified as left or right shells (Fig. 1c). Chitons, or coat-of-mail shells, have eight separate shells, or valves, per animal, of which the posterior and anterior valves are readily distinguishable from each other, and from the six median valves (Fig. 2a).

*Fig. 2a*
*Parts of a chiton shell.*




The phylum Mollusca also includes the class Cephalopoda, or many-armed molluscs. It is not unknown for bits of cuttlefish gladius (shell) to turn up in middens (Fig. 2b). Anyone who has ever given cuttlebone to their budgie should recognise these by their texture, which is light and cellular.

Some species of crustaceans may be represented in middens. The tips of crab claws are sufficiently calcareous to survive in the average midden, and are usually recognisable as such. Specific identification usually needs to be done by a specialist. In southern sites especially, crayfish (spiny lobsters) may be recognised by their mandibles (Fig. 3a). These have only recently been identified as such in Australia; a detailed account of New Zealand examples may be found in Leach & Anderson (1979).

Echinodermata may also turn up in the form of sea urchin test fragments, spine fragments, or 'teeth'; eight of the latter make up the jaw apparatus called 'Aristotle's lantern' (Fig. 3b).

It is useful for the fieldworker to attempt to make a reference collection of her own for the area in which she is working. Ideally, live animals should be collected, and a range of individuals within each species at different times of the year. Weight of shell to weight of flesh ratios may be calculated (as in Coleman, 1966 and Bowdler, 1970) and so forth. More ambitious surveys of the 'standing crop' might be attempted (e.g., Shawcross, 1967; Terrell, 1967). In less than ideal conditions, simply having one example each of the most commonly

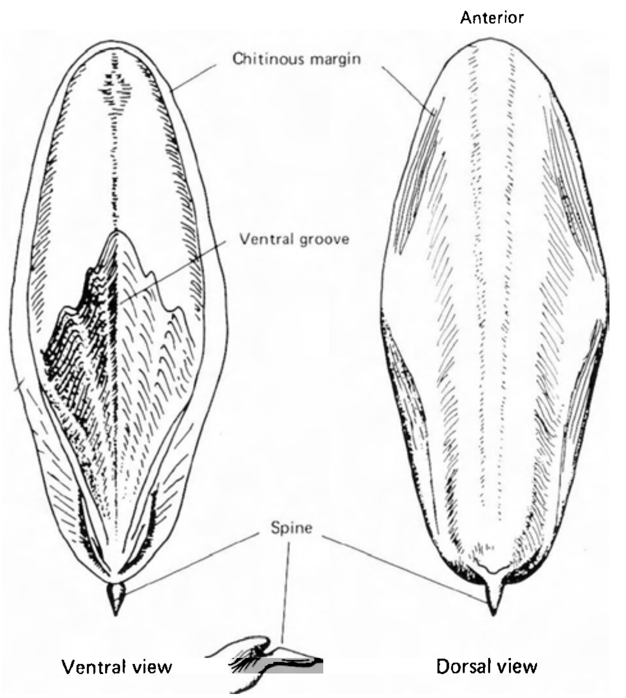



*Fig. 2b*
*Parts of cuttlefish gladius (based on Macpherson & Gabriel, 1962).*




*Fig. 3a*
*Surviving parts of crayfish mandibles.*

occurring local molluscs, crabs, sea urchins, etc., is helpful.

The following comments have kindly been contributed by Keryn Kefous:

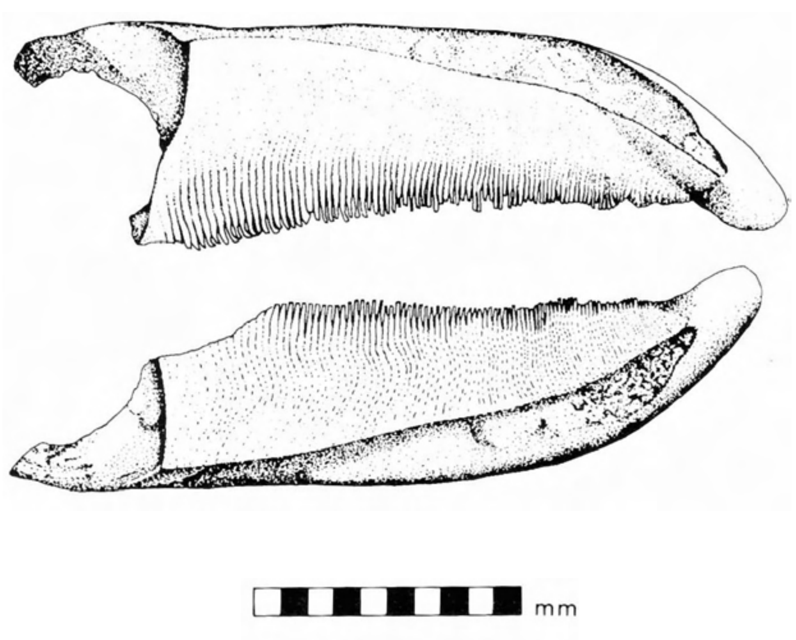
> Inland middens in arid areas contain, in addition to bivalves, gastropod fragments: the remains of freshwater crayfish and yabbies, *Cherax* spp. and *Etruscus* spp. The most common part preserved is the gastrolith or 'stomach stone', which actually has nothing to do with the stomach, but represents an accumulation of calcium carbonate which the crustacea use to secrete a new shell after moulting. Gastroliths are round button-shaped objects, 10–15 mm in diameter. It is possible to calculate live weight and meat weight from the diameter of the fully-formed yabby gastrolith (Kefous, forthcoming). Gastroliths should not be used as seasonal indicators; in inland Australia, gastrolith growth may occur during any season when food is available to the crustacean. Other crustacea fragments commonly found include fragments of carapace and claws, which indicate genus, but not much more.

## Further analysis

This chapter has so far outlined some basic procedures in sampling shell middens and analysing the samples in such a way as to provide fairly low order, but essential, information about the density of shells within the sites and the relative importance of different species. There are many further analyses which might then be carried out, but these are on the whole beyond the scope of this chapter. The simplest and most obvious procedure which might be mentioned is that of measuring whole shells, or shells which are complete in some dimension such as width, height, length of operculum, and so on.

Shell measurements may be informative in two ways. On the one hand, it means that relative meat weights can be calculated with more accuracy than from simple minimum numbers estimates only (e.g., Coleman, 1966: 55; Bowdler, 1971: 220). Shell measurements may also suggest the age structure of the populations from which the archaeological samples have been extracted, from which in turn inferences may be

*Fig. 3b Sea urchin 'teeth' (drawn from specimens).*



drawn about the nature and duration of the human predation (e.g., Swadling, 1976, 1977a, 1977b). Some shells may have other characteristics besides size which indicate their age at death, although this does not seem to be well worked out for Australian species (see Swadling, 1976, 1977a, for Papuan and New Zealand species).

Growth ring analysis is often advocated as having great potential for establishing seasonality of shell fishing, amongst other things, but the methodology is not as yet simple or straightforward, and necessitates the use of a scanning electron microscope. It is to be hoped that the methodology and interpretation of shell growth ring analysis will be expedited in the future.

### Fish remains

Fish bones and otoliths should generally be treated in the same way as other vertebrate remains (see Jeannette Hope, Chapter 12). I mention them here as they are a common and important component in marine and inland middens (with the exception of Tasmania, see Jones, 1978). For useful approaches to identification and analysis, the reader is referred to Bowdler (1970), Barz (1977), and Coleman (1978) for temperate marine sites and Kefous (1977) for inland New South Wales sites. Barnett (1978) is invaluable for tropical sites.

## INTERPRETATION

This is, again, hardly the place for the detailed exposition of how to interpret the results of midden sampling and analysis. The reader is referred to the bibliography, and especially those references most commonly cited in this chapter, for an understanding of how to make reasonably sophisticated interpretations of her results. Again, some brief points are mentioned.

Some interpretation is clearly called for if similar sites contain different species, or proportions of species, of shellfish; or if such differences are observable in the same site or sites through time. Initially, such differences should be shown to be statistically significant through the use of appropriate tests. There is no reason to assume that shellfish numbers in archaeological sites, or in nature, are in any way normally distributed, so non-parametric tests should be used. Once these differences have been established the kinds of explanation tend to fall into one of the following categories: taphonomic, environmental/ecological, economic/behavioural. In the first instance differential survival value of different species might be considered; in the second a change of habitat might bring about a change of availability of species (e.g., Coutts, 1970: 90); in the third a change in gathering habits brought about by some purely cultural factor might be suggested (e.g., Bowdler, 1976). Clearly, other sorts of evidence must be taken into account; it is simply not possible to interpret one class of archaeological evidence while ignoring all the others.

In the end, one's interpretation is only as good as one's analysis, which is only as good as one's sample. In the case of midden analysis we are usually analysing small samples of the larger excavation, itself a sample of a site, itself a sample of a set of sites. Each stage of the sampling process should involve the same amount of consideration; each stage of the analysis should involve the same amount of thought and care. Ultimately, of course, the analysis will be no better than the consideration given to the reasons for doing it. A methodological exercise will only really serve to answer methodological questions, and it is to be hoped that we have gone beyond that now.

## ACKNOWLEDGEMENTS

The techniques described here have been evolved over the years with the practical and theoretical help of many people; in particular I thank Ron Lampert, Carmel Schrire (White), Rhys Jones, and Phil Hughes. I am grateful to Hilary Sullivan for clarifying my thoughts about the purpose of this exercise. I also thank Marjorie Sullivan, Julia Coleman and Harry Lourandos for reading the draft of this chapter, Wendy Chappeli for typing it, and Doug Hobbs for the illustrations.

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*Note:* Chapter submitted in 1979.

# Chapter 14

# Radiocarbon dating: a guide for archaeologists on the collection and submission of samples and age-reporting practices

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A model describing the production, distribution, and decay of the radioactive isotope of carbon ($^{14}C$) led to a proposal that the $^{14}C$ content of an organic sample could be used as an index of age. Between 1947 and 1949 Willard F. Libby conducted the critical experiments which established the basic validity of the method. Since that time all of the six basic physical assumptions of the method have been the subject of continuing scrutiny. Archaeologists who rely on $^{14}C$ values to construct their chronologies are especially concerned with errors that may be introduced as a result of violations of one or more of the fundamental assumptions. Error reduction strategies are best implemented by close interdisciplinary collaboration and cooperation between radiocarbon specialists and those engaged in archaeological research studies. (Taylor, 1978: 33)

This chapter, a revised and shortened version of the original paper (Polach & Golson, 1966), deals with basic matters relating to the collection and submission of samples, while a new section briefly touches on radiocarbon dating age-reporting practices.

## COLLECTION OF SAMPLES

### Amount of sample to be submitted

It is very important that an adequate size of sample be collected and submitted. Since different types of material contain differing amounts of carbon, sample size varies considerably. In some cases environmental interaction with the sample may result in a loss of original carbon-containing material and this is usually indicated by the appearance of the sample. If it looks degraded by comparison with 'normal' material of the type, a larger amount of sample needs to be submitted. Environmental interaction may also result in the incorporation of foreign carbon with the original carbon in the sample. This foreign material needs to be removed in the laboratory before the sample is suitable for dating. A dating laboratory therefore needs detailed information about the environment in which the sample was collected so that an appreciation of the possible complications in obtaining a valid date can be gained. If the sample is pretreated to remove possible contaminants before dating a certain amount of material will be lost. These losses can be as low as 1% if the sample is good quality wood or charcoal but may rise to as much as 80% or more if the sample contains soft fragmented charcoal dispersed through a sand or soil matrix.

Obviously the collector cannot be expected to know the appropriate amount needed for the particular sample he or she is collecting. Table 1 therefore attempts to give some general figures for his or her guidance.

Under the heading *dry weight,* the first column gives the absolute minimum which the Australian National University Dating Laboratory can handle. These minimal amounts are only acceptable if it is impossible to collect more material. As pretreatment of such small samples is not possible it must be realised that they may suffer from contamination the magnitude of which cannot be assessed, so that ages from minimal samples must always be suspect. Furthermore, with samples of minimal size, it is often the case that only age limits can be obtained. Such limits are expressed as greater than (>) or less than (<) a given $^{14}C$ age value.

The second column gives the desirable amounts for samples of different types. These amounts are enough to allow standard pretreatment and sample purification of samples with ages up to 36 000 BP (before the present, i.e., AD 1950). Should age determinations beyond this limit be required double or even treble the desirable amount must be submitted. The Australian

*Table 1*

**AMOUNTS OF MATERIAL TO BE COLLECTED FOR RADIOCARBON DATING**

| *Material* | *Dry weight* | | *Comments* |
|---|---|---|---|
| | *Minimum (g)* | *Desirable (g)* | |
| **Materials generally suitable** | | | |
| Wood, clean or rotten | 5 | 25–30 | |
| Charcoal | 2 | 10–20 | rich, black flakes |
| | 5–10 | 50–200 | sandy, brown |
| Shell | 20 | 100 | hard, shiny surface |
| | 30 | 150–200 | powdery or pitted surface |
| Grass, leaves | 5 | 35–50 | |
| Paper, cloth | 3 | 25–30 | |
| Peat, gyttja | 30 | 80–120 | dark brown |
| | 60 | 150–200 | light grey-brown |
| **Materials for special projects in collaboration with dating laboratory** | | | |
| Bone: apatite | 500 | 1000 | up to 20 000 years BP |
| carbonate | 200 | 600 | seldom yields valid date |
| collagen | 300 | 800–1500 | up to 10 000 years BP |
| charred | 500 | 1500–3000 | up to 36 000 years BP |
| Soil: organic matter | | 2000–5000 | humic acids and humins |
| carbonate | | 100–500 | pedogenic and nodules |

National University Laboratory's age limit under these circumstances is 50 000 BP.

All weights apply to dry, clean materials. Collectors dealing with waterlogged materials must compensate for the weight of water, possibly up to 90% of the total, when collecting porous samples like charcoal and wood. The dry weight of material is difficult to judge in the field, so the collector should aim for a certain bulk, as set out below (the bags referred to are 15 cm × 30 cm plastic bags).

*Wood*

One piece 3 cm in diameter and 25 cm long, or equivalent, if the wood is solid. With waterlogged wood, particularly if soft and spongy, it is best to treble this quantity, as the degree of shrinkage on drying is hard to predict.

*Charcoal*

(1) Pieces separated from soil and sand as far as possible:
   (a) dark, lustrous, well defined wood grain, brittle: 1/8 bag (a heap covering the palm of one hand);
   (b) grey-brown, either hard (mineralised) or soft and smeary (leached), no defined wood structure: ½ bag or more.

(2) Small particles, too small for efficient separation in the field:
   (a) definite grains in soil or sand: 1–2 full bags;
   (b) finely disseminated charcoal in soil or sand, smudging the matrix on trowelling rather than being seen as definite grains: at least 5 full bags.

*Peat gyttja*

(1) Dark brown, fibrous, obviously rich in organic debris: ¼ to ½ bag (5–10 cm or 4 cm core).

(2) Light brown, no fibrous material, gritty or greasy (clayey) feel, no discernible organic debris: one full bag (10 cm of two adjacent 4 cm cores or 20 cm of one 4 cm core).

A safe rule for all collectors is to collect as much sample as possible. Smaller amounts than those stated should be submitted only when it is physically impossible to collect more. Larger amounts than those recommended will ensure adequate pretreatment and may provide duplicate samples. It is also helpful to collect samples of more than one material from a single horizon, as additional determinations may be required should there be age inversions or discrepancies with expected age, or if it becomes essential to increase the precision of individual determinations, for example when checking for contemporaneity between sites or dealing with samples older than 36 000 years. The laboratory should be informed at the time of sample submission, if such crosscheck samples exist.

## Handling of samples

The collector should minimise the amount of sample handling in the field. However, there are some preliminary tasks that he or she can do under proper workroom conditions which will help with the work load of the dating laboratory.

Separation of the sample from soil or sand or removal of rootlets can be undertaken by sieving or hand picking using tweezers. More complex methods of separation should be left to the staff of the laboratory. The surface of bone or shell samples can be cleaned using steel, brass or stiff nylon brushes. Organic fibres and paint brushes should not be used under any circumstances. Samples are best submitted to the laboratory in their natural moist state. Peat samples, for example, should never be dried.

Waterlogged samples should be packed in the normal way (see later) and submitted directly to the laboratory. In many cases physical and chemical separation or purification is adversely affected when the sample has dried out. Fungicides should never be used; if fungal growth has occurred, this can be recognised and removed in the laboratory.

In a few cases, an organic artefact which the archaeologist needs to protect with fungicides or preservatives for study purposes may also be required as a sample for radiocarbon dating. Recent study at the Australian National University has shown that Carbowax (polyethylene glycol 400) can be removed from wood. However, prior consultation with the dating laboratory should take place.

## Suitability of various materials for dating

*Woody materials*

Wood is an excellent dating material if it is in a good state of preservation, but structural and compositional changes can occur over relatively short periods of time depending on micro-environmental factors which can vary greatly. Hence it is advisable for the submitter to supply as much information as possible about the locality from which the sample was taken. This enables the laboratory to determine the most appropriate pretreatment technique. Some of these result in the loss of a large amount of sample. This means that, if contamination is postulated, small sample sizes may result in $^{14}C$ ages whose accuracy cannot be evaluated.

The collection of charcoal, if it exists in fairly large discrete fragments, is usually straightforward, as is the normal laboratory pretreatment. The charcoal is first cleaned and any rootlets or surface contaminants are removed. If the charcoal is hard, dry and brittle and has come from an arid or well drained environment, the laboratory will need to wash it in hot dilute hydrochloric acid to remove possible carbonate contamination. If the charcoal is soft and easily crushed or has come from a site covered by vegetation, it is treated in the laboratory alternately with dilute acid and alkali to remove humic contaminants or isolate humic and human fractions for dating. This method of pretreatment usually results in heavy losses of material.

Sometimes the only available charcoal may appear as flakes dispersed through a soil horizon, hard and mineralised in sandy environments, soft and smeary in clayey soils. In this case separation is impossible under field conditions and the total charcoal plus soil should be submitted to the laboratory, where suitable techniques can be used to concentrate or isolate the charcoal. Grave errors are often made by collectors in estimating the approximate carbon content of the charcoal–soil mix and very often insufficient sample is submitted to meet the laboratory's minimal needs. It is therefore advisable for the collector to obtain as much material as is possible under these circumstances.

*Shell, marine*

There are many problems associated with the use of marine shells for radiocarbon dating.

The initial $^{14}C$ concentration in marine shells at the time of growth is in equilibrium with the $^{14}C$ concentration of the bicarbonate ($HCO_3^-$) and the dissolved $CO_2$ in the seawater; in all cases seawater $^{14}C$ is not in equilibrium with atmospheric $^{14}C$. The $^{14}C$ concentration in seawater also varies greatly from site to site depending on latitude and the influence of ocean currents. Hence shells living in 1950 (i.e., prior to contamination of atmosphere and oceans by $^{14}C$ produced by atomic weapons) at different localities in Australia could have an *apparent* $^{14}C$ age from 250 to 750 years. Satisfactory solutions for these problems

have been achieved for some areas of the world and the appropriate corrections for shell dates in these regions can be made by the dating laboratory. For the east coast of Australia, Gillespie & Polach (1979) have estimated that the *apparent* age of shells is $450 \pm 35$ years, i.e., $^{14}C$ dates of shells from this region are too old by that number of years. Any collector who is lucky enough to find charcoal in direct association with shell, and is confident that the two are contemporaneous, is strongly advised to submit both. This enables the laboratory to see the relationship between the two and thus check if the postulated *oceanic environment correction factor* is appropriate. Unfortunately, to collect living shells to serve as a modern reference standard is seldom satisfactory because of variable enrichment of contemporary materials by atom-bomb-produced $^{14}C$.

It is wise to consider that shell dates without any means of control can be quite misleading, as apart from these general problems local environmental conditions will influence the *apparent* age of shells. For instance, shells from closed estuaries or harbours will be affected by limited seawater circulation and an increase of fresh water from rivers and runoff, hence appearing to be younger, or by old terrestrial limestone washed in by rivers, hence appearing to be older. Therefore, shells collected for routine dating should ideally be species whose habitat is open ocean beaches.

There are also problems associated with the conditions to which shells are subject after death, including the possibility of post-depositional contamination with young or old forms of carbon in solution. Most laboratories attempt to guard against this during pretreatment by removing a thin layer of carbonate from the surface of the shell, using dilute hydrochloric acid. The amount removed varies from 5% to 40%, according to the state of preservation of the shell. Hard surfaces which have retained their lustre can be reasonably expected to be free of contamination, though this is not necessarily so as another form of contamination, namely recrystallisation, may have occurred. Some shells naturally deposit their carbonate as aragonite, others as a mixture of aragonite and calcite and yet others as pure calcite. Radiocarbon daters prefer aragonite shell, since when external carbonate enters the crystal lattice of shells, in the process known as recrystallisation, it does so in the form of calcite. In some species it is possible to distinguish microscopically between original and secondary calcite, but this is a highly specialised field not really within the normal scope of a radiocarbon laboratory. If the surface of shells is soft and the shell is mottled (has a variable milky to opaque appearance in cross-section) the Australian National University Laboratory will remove these surfaces physically and carry out comparisons of inner and outer shell layers to validate their dating. This is of greatest value when shells are suspected to be of high antiquity, as modern contamination would result in a significant change in age (see later section on contamination).

When all of these problems are taken into consideration, it is obvious that the dating of marine shell material is not straightforward and it is advisable for the collector to consult freely with a $^{14}C$ laboratory. In many cases the use of shells for dating should be considered only as part of a coordinated research programme.

The collector, when submitting shells for dating, should wash off all soil, sand and debris and air-dry the samples prior to packaging. Fresh or sea water can be used for washing. The sample should consist of one species only, preferably large single shells rather than small fragments. This, of course, is not always possible. Small fragments can be recovered from a soil horizon by sieving and washing, but the validity of $^{14}C$ ages thus derived needs to be tested.

### *Shell, freshwater and terrestrial*

The same possibilities of environmental contamination apply to these shells as to marine shells and the same treatment applies. However, the influence of the environment during life becomes of paramount importance since freshwater and terrestrial shells assimilate carbon from purely local sources. Since such environments can vary greatly only a careful study of the conditions in which freshwater species live can validate the $^{14}C$ ages derived from them.

Such a project should be undertaken only in cooperation with an interested radiocarbon dating laboratory. Care must be taken when submitting shells to avoid mixing these types with shells of marine origin. In summary, they should only be considered for dating if a comprehensive project is envisaged.

### *Bone*

Much controversy still surrounds the dating of this material and the validity of dates obtained is often questioned. This is due mainly to the extremely porous nature and low carbon content of the material, which together allow inorganic and organic carbon carried by groundwater to alter the bone age.

The carbon in bone exists in both organic and inorganic forms. The organic component makes up about 20% of fresh bone and consists mostly of collagen together with a few other proteins and fats. Collagen contains about 50% carbon, which means that fresh bone should contain about 10% organic carbon. Collagen breaks down into soluble components depending on the environment with which the bone is associated, and these components are leached out of the bone. With badly preserved bone the organic carbon may be less than 1% or even non-existent. Many of the treatments used for isolating organic carbon are not very efficient. This means that large amounts (in excess of 1 kg) of bone must be submitted for dating.

The inorganic component makes up about 80% of fresh bone and a small amount (*c.* 8%) of calcium carbonate is incorporated in the complex apatite mineralogical structure. There is evidence that soil-derived calcium carbonate can become part of the bone apatite structure as degradation occurs. On the other hand, carbonate encrustation may assist the preservation of bone organic matter.

Many pretreatment techniques have been used in the isolation of both organic (collagen) and inorganic (apatite) bone components, both of which can be useful under certain specific conditions. Hence, close cooperation between the collector and the dating laboratory is necessary if any useful information at all is to be derived from bone dates. Charred bone is suitable for dating if sufficient organic carbon originating from collagen can be isolated from the charred remains.

Most researchers dealing with $^{14}C$ dating of bone are of the opinion that bone dates in general, collagen as well as apatite, tend to be younger than the true age.

When bone samples are collected the specimens are best wrapped in aluminium foil when found and the cleaning and chemical purification left entirely to the dating laboratory.

### *Meat and flesh*

These materials have so far not been found in Australian archaeological sites. If they are to be collected to serve as a modern reference standard, for example to study the relationship between flesh and the carbonate of a shell, arrangements for their

preservation should be made prior to collection. A vacuum flask filled with dry ice will keep a specimen frozen for a long time. Materials of this nature should never be sent by post or be given for delivery to persons who do not appreciate their perishable nature. The processing laboratory should be advised that the sample is in transit.

*Peat*

Peat is a term applied to material accumulated *in situ* in limnic or terrestrial habitats from plants which have their green parts in the air and thus assimilate carbon dioxide from the atmosphere during growth. Besides being completely autochthonous, peat generally grows so quickly that the time scale through a deposit is elongated in a way that makes it sometimes possible to collect pairs of samples to check the dating of any one horizon vertically as well as laterally.

It is true that there can be some movement of humic materials in solution from one level to another, but these can be eliminated fairly readily in the laboratory, leaving the actual material that formed *in situ*. Again, there is a source of error in the fact that the roots of one generation of bog plants grow down through material already formed but owing to the high water-table this penetration is seldom very great. The exception would be former peat beds, now elevated above the water-table and supporting shrub or forest type vegetation, whose deeply penetrating root systems, and the decay products thereof, introduce contamination not readily eliminated. Under these circumstances, dating the older, originally deposited material becomes essential and double the quantities indicated in Table 1 must be collected to allow for both physical separation of constituents and their chemical decontamination in the laboratory.

*Lake muds (gyttja)*

Lake muds consist largely or exclusively of the organic remains of submerged plants which assimilate their carbon as the bicarbonate ion from the water as well as from dissolved atmospheric carbon dioxide. The two sources of carbon are of different $^{14}C$ activity. The atmospheric carbon dioxide is richer in $^{14}C$ activity, while the bicarbonate ions can be depleted in $^{14}C$ if they are solution products of limestone deposits in the catchment area. The organic muds may also incorporate transported matter from an original deposit of unknown age. Radiocarbon age determinations may therefore yield false results.

Collectors who are interested in lake muds as dating material must take all of the above points into consideration. They must obtain information as to the biological origin of the muds and evaluate possible effects from old limestone or organic deposits elsewhere in the area, as well as a host of other environmental factors. This means that cooperation between experts in many fields may be prerequisite for the production of a valid age sequence.

*Soils*

Radiocarbon dating is applicable to all soils containing biogenic carbon, either as organic carbon or secondary carbonates. Datable organic carbon fractions are derived from degraded plant and animal remains and charcoal, while mineral carbon derives from reworked carbonates secondarily precipitated in the soil. Fossil organic and parent limestone materials are unsuitable because they no longer contain $^{14}C$. Physical relocation, chemical transformation and intrusive contamination of datable material within a soil are factors which need to be evaluated in order to assess the meaning of a $^{14}C$ determination. Low carbon content of soils increases the difficulty of dating them.

Notwithstanding the above, much significant work has been done overseas and at the Australian National University Laboratory, dating soil organic and carbonate fractions in pedological and climatological studies (Yaalon, 1971). The significance of the Australian National University work for the archaeologist, in particular, lies in the fact that soils (in one form or another) are the medium in which datable archaeological material is most often located. The transfer of organic matter to samples like charcoal or wood must therefore be considered when devising decontamination procedures. Soil organic matter extraction techniques also find direct application within an archaeological site, when organic debris dating the activities of man, while concentrated in horizons within a site, is nevertheless finely dispersed and intimately intermixed with a soil matrix. In one such case Polach (1972) demonstrated, using soil organic and inorganic fraction separation techniques, that the human occupation debris could be isolated and validly dated.

Soil samples are best treated as part of a comprehensive study involving a team of workers from many scientific fields. Collection of the sample, assessment of its relationship to the immediate environment and the recognition and separation of a reliable dating fraction, require a variety of extremely specialised skills. The value of isolated samples is therefore questionable and we do not recommend their use.

*Lime mortars*

The feasibility of determining radiocarbon ages for these materials has been demonstrated recently (Folk & Valastro, 1979) and the possibility of obtaining apparently valid dates from them should not be overlooked. Only a few laboratories appear to have practical experience with these media and not all laboratories may be willing to accept materials of this type. Collectors, however, may interest a laboratory in undertaking a project using such material for radiocarbon dating.

## COMMENTS ON CONTAMINATION

The need to purify, hence physically and chemically pretreat, samples submitted for radiocarbon dating has been stressed in the foregoing paragraph. It arises from the fact that the sample in nature is exposed to $^{14}C$ activity which differs from its activity. The environmental activities are invariably either greater, producing a younger age, or less, giving an older age. Hence, not enough emphasis can be placed on the need to assess the cross-talk between sample and environment and, based on this, devise techniques which will minimise it. In this section we wish to point out that contamination effects can be quantified only if (1) the age of the contaminant and (2) the percentage contribution of contaminant carbon to sample carbon are known. Dating of fractions isolated from the same sample cannot be undertaken by $^{14}C$ dating laboratories as a matter of routine. Routine pretreatment will minimise contamination effects, often to predictable limits, but it does not validate the age of a sample.

This circumstance cannot, however, be used as an excuse by archaeologists as to why *their* radiocarbon dates are in *their* opinion wrong. It usually is possible to infer the change in age which contamination might induce in terms of direction and magnitude. In doing so the laboratory makes use of its own experience as well as the research of others. Figs 1 and 2, originally published by Olsson (1974) and subsequently discussed by Polach (1976) and Taylor (1978), would form the basis of estimates of the direction and magnitude an age change would take. A laboratory, when

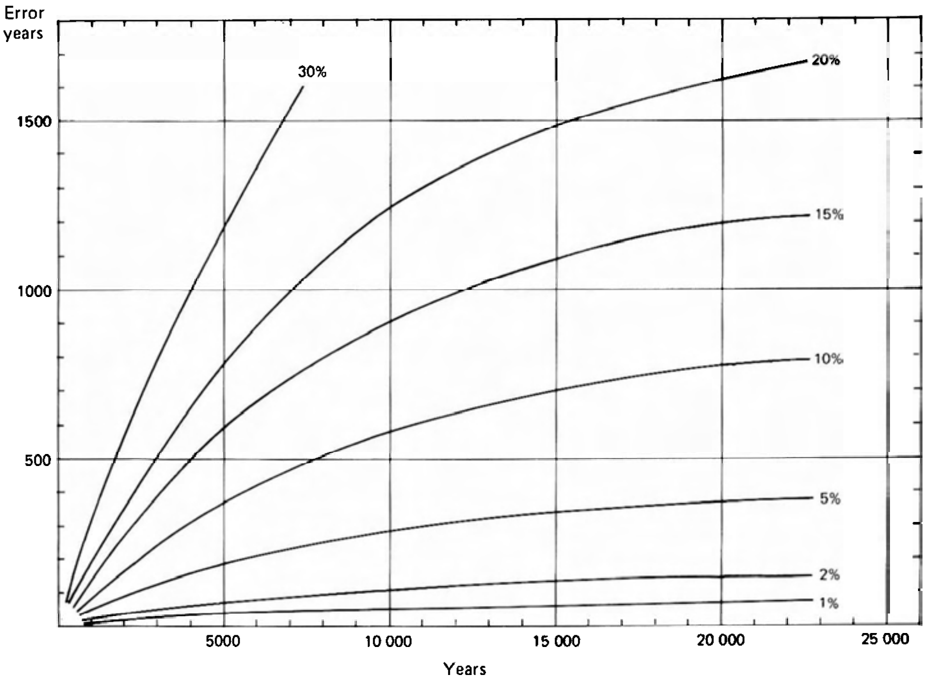



*Fig. 1*
*Difference in true age of sample incorporating older contaminant. Apparent age of sample in $^{14}C$ years BP is given along ordinate. The abscissa gives induced error for 1–30 % contamination by older carbon (less $^{14}C$ activity) than sample to be dated. The combined age of sample + contaminant (the apparent age) will be greater (older), hence the induced error in $^{14}C$ years (abscissa) must be SUBTRACTED from it to obtain 'true' age BP (After Olsson (1974) see also discussion in Polach (1976) and Taylor (1978)).*

reporting results based on any pretreatment, merely states that it attempted to isolate from the sample as submitted suitable material for dating. This, the laboratory did often using routine techniques, or techniques developed by it to answer specific questions of validity. Either way, the laboratory was aware of the limitations imposed by the sample, such as its size, its chemistry, its environment, as well as those imposed by considerations of effort in relation to archaeological need for higher precision. For routine dating such considerations tend to minimise effort in order to maximise output. Such is certainly the case at the Australian National University.

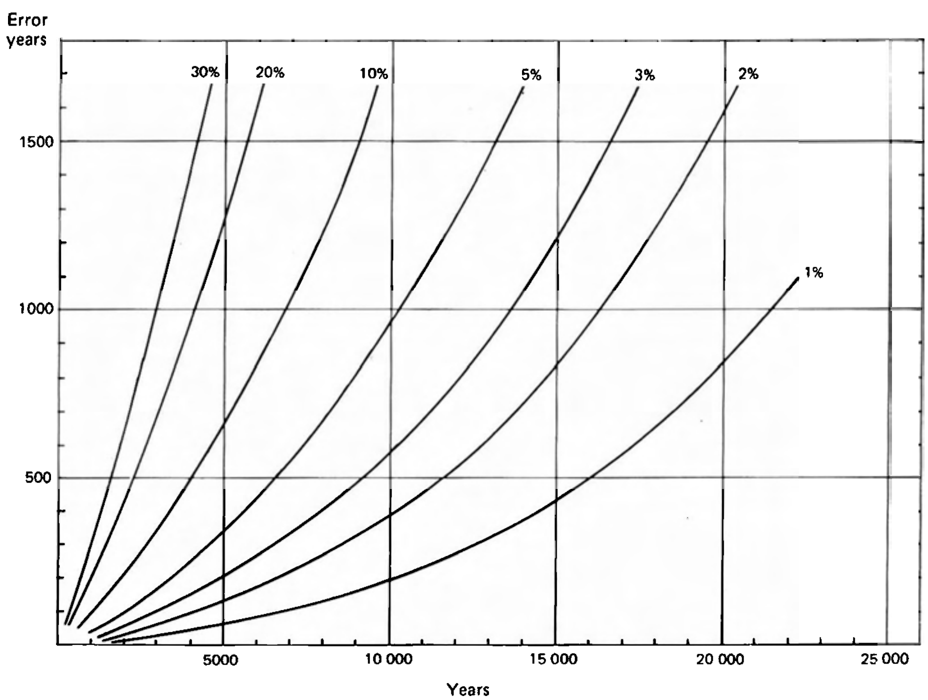
## SUBMISSION OF SAMPLES

### Packing

Many different kinds of container have been used by collectors for their radiocarbon dating samples. We favour a heavy grade of polythene bag. Paper and thin plastic bags as sold at supermarkets are quite unsuitable. Glass jars or bottles are subject to breakage, while drink, food and tobacco containers may be sources of contamination. Special packaging for certain types of sample has been referred to above.

A suitable size of polythene bag is 15 cm × 30 cm. Two should be used for each sample. The mouth of the bag containing the sample should be folded over twice, stapled down and put inside the second bag which is then closed in the same way. The collector's own sample code number, his or her name, date of sample collection and site identification should accompany the sample in a secure fashion, ideally written on an index card which is placed between the two sample bags. Alternatively, the sample in its plastic bags may be enclosed inside a thick-walled paper bag and the requisite information written on the outside of this. Writing directly on the outside of plastic bags should be avoided since the writing tends to rub off. Paper labels in the same bag as the samples are unsuitable. Do not use

*Fig. 2*
*Difference in true age of sample incorporating younger contaminant. Apparent age of sample in $^{14}C$ years BP is given along ordinate. The abscissa gives induced error for 1–30 % contamination by younger carbon (higher $^{14}C$ activity) than the sample to be dated. The combined age of sample + contaminant (the apparent age) will be lesser (younger), hence the induced error in $^{14}C$ years (abscissa) must be ADDED to it to obtain 'true' age BP (after Olsson (1974); see also discussion in Polach (1976) and Taylor (1978)).*



loose material such as sawdust, straw, perlite, vermiculite, wood wool and cotton wool to pack between samples or to take up space in an excessively large box.

To avoid loss and excessive handling of samples, always send them directly to the person in charge of a dating laboratory, remembering to enclose relevant information (for example, copies of a sample record sheet) within the parcel.

Most laboratories will acknowledge the receipt of samples immediately, but should you not be advised do not hesitate to make enquiries as to the whereabouts of a sample.

### Filling in the sample record sheet

All laboratories require information pertinent to each of the samples submitted. Most laboratories have printed forms or sample record sheets for this. These forms should be obtained prior to going into the field. While the remarks that follow apply particularly to the sample record sheet adopted by the Australian National University and the University of Sydney, they are generally applicable to all dating laboratories.

The information accompanying a sample at the time of submission, apart from giving the name of the submitter and the collector's sample code number, should also include a detailed sample description, accurate location of the site where it was collected (complete with latitude and longitude) and full stratigraphic and environmental details. An estimate of age, with brief justification, is valuable to the laboratory and is essential in the case of samples of minimal size. With full information the laboratory can judge whether contamination is likely to have occurred and thus apply an appropriate sample purification procedure. If the laboratory obtains a result at variance with the submitter's predictions, it can undertake an assessment of the relationship between sample and event to be dated. The *environment and lithology*, e.g., bog, glacial deposit, marine sediments, gravel, sand, silt, etc., and *chemical environment*, e.g., limestone, hard or soft water, no water, continually submerged, seasonal flooding, fluctuating water-table, exposure to elements, pH and nature of soils (high humic content, etc.), penetrating rootlets, etc., must be fully described. Any collector-induced contamination, such as field preservation by Carbowax, must be clearly indicated. There should be a clear statement also as to the reasons for dating and the significance of results.

The record sheet should be typed in duplicate and a copy retained by the collector. All entries should be filled in. Where insufficient space is available for the answer to any entry, there is usually room provided elsewhere on the form to complete the reply. If this is insufficient, attach a separate sheet. Drawings and photographs can be particularly useful in giving information about the sample and its environment.

Each sample submitted must have its own sample record sheet. Some of the information will repeat itself for a given site, but the chore of submitting a fully completed form for each sample should be weighed against the advantages of adequately informing the dating laboratory of all factors relative to a sample.

The collector may anticipate some difficulty in providing information about pH of soils, something which the Australian National University Laboratory specifically requests. One solution is to submit a spoonful of soil to the dating laboratory at the same time as the sample. Alternatively, a simple test can be carried out in the field. Place a teaspoonful of soil in a cup; cover it with distilled water (approximately three tablespoons); let the soil settle; then dip a pH indicator paper in the liquid. A comparison against a colour code supplied with the test papers will give a pH reading with an error within 0.5 of a unit. Suitable pH indicator papers are BDH pH ranges 2.5–4.0, 4.0–5.5, 5.5–7.0, 7.0–8.5, 8.5–10.0. Booklets of these can easily be taken into the field. Simple pH test kits are also readily available.

## REPORTING OF $^{14}C$ AGES

### The age and its error

A $^{14}C$ result is quoted as: *laboratory code* and *sample number* followed by *age + error* in $^{14}C$ years *BP*.

When reporting and applying results, a $^{14}C$ age must never be dissociated from its laboratory code, sample number and error term, because they uniquely identify the sample.

The age is reported in CONVENTIONAL RADIOCARBON YEARS BEFORE PRESENT (BP). By international convention (Olsson, 1970), this means that:

(1) The age is stated in $^{14}C$ years Before Present (BP), which is AD 1950, the accepted radiocarbon reference year.

(2) The age determinations are related to 95% of the $^{14}C$ activity of the National Bureau of Standards (NBS), Washington, DC, Oxalic Acid International Radiocarbon Dating Standard, normalised for stable isotopic fractionation to the base of $\delta^{13}C = -19.0‰$ PDB, the marine Belemnite standard from the Pee Dee Formation (Craig, 1957). The use of secondary standards, such as ANU-Sucrose, is permissible if its activity is related directly to NBS Oxalic; ANU-Sucrose is normalised to the base of $\delta^{13}C = -25.0‰$ PDB (Polach, 1979).

(3) The measured $^{14}C$ activity of a sample is corrected for stable isotopic fractionation to the base of $\delta^{13}C = -25.0‰$ PDB, i.e., the value of terrestrial wood.

(4) Ages are calculated using the Libby half-life of 5568 (5570) years.

(5) The stated error only takes into consideration uncertainties in precision of measurement of $^{14}C$ and $^{13}C$; it is expressed as plus or minus ($\pm$) one standard deviation (probability = 68.3%).

(6) The age plus error is independent of uncertainties associated with $^{14}C$ half-life determination and past variations of radiocarbon concentrations in the atmosphere.

(7) The $^{14}C$ result is an expression of age in radiocarbon years BP and a series of results constitutes a *radiometric* and not an *absolute* chronology.

As discussed in the journal *Radiocarbon*, Stuiver & Polach (1977) further recommend:

(8) The reporting of the millesimal (‰) enrichment (+) or depletion (−) value of $^{14}C$ activity of a sample with respect to the $^{14}C$ activity of the standard, both corrected for isotopic fractionation. If given, it is annotated $D^{14}C‰$.

(9) The reporting of measured or estimated $\delta^{13}C$ stable isotopic ratios with respect to the PDB standard; where estimates of $\delta^{13}C$ are made, these could be based on values published by Stuiver & Polach (1977).

(10) The retention of the maximum number of significant figures in the $D^{14}C$ values; the ages, in radiocarbon years BP, should however be rounded off.

Not all laboratories accept these recommendations. Indeed, some use a different half-life and some do not correct

*Table 2*

ACCURACY OF RADIOCARBON DATES (Polach, 1976, 256)

| *Sources of error* | *Effect on age determination* | *How to minimise error* |
|---|---|---|
| 1. Precision of age determination | Statistical, typically ± 1% Modern or less | big samples, optimal counting times |
| 2. Inherent | | |
| (i) $^{14}C$ half-life | 'Libby' H/2 probably ~ 3% too low | multiply ages BP × 1.030 |
| (ii) $^{13}C/^{12}C$ fractionation | 410 years is common in shell, 350 years is possible | Mass-spectrometry on portion of sample $CO_2$ |
| (iii) $^{14}C$ modern Std | <80 years | international cross-checking of secondary standards |
| (iv) Variations in past $^{14}C$ production rates | nil to ~800 years; beyond 10 000, BP not determined | tree-ring calibration; otherwise interpret in terms of *radiometric* time scale |
| (v) Distribution of $^{14}C$ in nature | surface ocean latitudinal dependence −400 to −750 years, deep ocean −1800 years | interpretation of results, choice of *contemporary standards* |
| *(vi)* Changes of $^{14}C$ concentration in the atmosphere | industrial effect *c.* −2.5% and atom bomb effect, *c.* +160% in atmosphere | interpretation of results |
| 3. Contamination | nil to 3000 years up to 15 000 BP, >10 000 possible beyond 25 000 BP | interpretation of results |
| 4. Biological age of material | <10 years to >1000 years | choice of material and interpretation of results |
| 5. Association of sample and event | indeterminate | interpretation of results |
| 6. Human | indeterminate | care in field and laboratory |
| 7. Interpretation of results | indeterminate | care in interpretation, interdisciplinary collaboration |

for isotopic fractions. This becomes important principally when comparing results from one laboratory with those from another.

The Australian National University Laboratory further states that:

(11) The validity of each $^{14}C$ age determination needs to be assessed in the light of *other* sources of error.

(12) Translation of a radiometric age into a calendar age, based on any of the so-far-published dendrochronologically derived correction tables or graphs is undertaken only at the *user's risk.* None of the known correction schemes is absolute or universally applicable (cf. Michael & Klein, 1979; Polach, 1982).

### Validity of radiocarbon dates

We have indicated above that by convention radiocarbon daters report age determinations in years BP and have stressed that these cannot be taken as *absolute* ages. We have also demonstrated that the precision of measurement, even today, remains the only error that can be subject to a strict statistical treatment and hence is the only error reported by the $^{14}C$ dating laboratory.

As a systematic guide through the maze of considerations that determine the overall accuracy, hence validity, of each radiocarbon date, we list in Table 2 other sources of error that need to be considered when assessing $^{14}C$ age determinations.

It is not our intention to comment further on Table 2; this has been done in the text from which the material has been extracted. However, we reiterate that the *age +error,* as reported by a radiocarbon dater, can be a *misleading artefact,* since:

> the accuracy of a radiocarbon age determination cannot be considered to be related (directly or indirectly) to the precision of sample residual $^{14}C$ activity determinations; validity of a radiocarbon age determination must suffer whenever equal attention is not paid to the other sources of error. (Polach, 1976: 293)

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*Note:* Chapter submitted in 1981.

# Chapter 15

# Radiocarbon concentration variations in the atmosphere and absolute chronology: how to interpret dendrochronological evidence

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Since the inception of $^{14}C$ dating the major error that has been made has been to accept $^{14}C$ results as *absolute* dates. Indeed, Willard F. Libby (1949) warned that the assumption on which the $^{14}C$ dating method is primarily based—that the concentration of $^{14}C$ (related to $^{12}C$) in a sample today represents the $^{14}C$ concentration in the sample when it was living (or deposited) thousands of years ago—needs to be tested. First documented evidence of past variations of radiocarbon concentration in the atmosphere was presented by Hessel de Vries (1958) who thus established the need to consider $^{14}C$ age determinations in $^{14}C$ years BP on a *radiometric* scale and not an *absolute* time scale representing calendar years. This is so because all terrestrial plants depend solely on atmospheric carbon dioxide ($CO_2$) for their source of carbon. Consequently, past changes in $^{14}C$ concentration of atmospheric $CO_2$ are reflected in plants that lived then. Radiocarbon daters have known for some time and with considerable certainty that a wood sample from *c.* 5000 BC would yield a $^{14}C$ 'age' nearly 750 years too young, while with samples from *c.* AD 1200 the $^{14}C$ 'age' would not be different from the true age. Not surprisingly the past 15 years have seen a proliferation of calibration curves and tables, some of them produced by $^{14}C$ laboratories such as Tucson, MASCA, La Jolla and Seattle, others the result of individual workers taking the same data and intuitively and/or statistically re-interpreting the results.

There can be no pretence that the curves and tables thus far produced are comprehensive. Each encompasses not only complex and often contradictory data but also strong personal views which undeniably are biased either towards smooth curves, such as proposed by Colin Renfrew and Malcolm Clark (Clark, 1975), or wiggly curves, the richest in 'schwung' being that of Hans Suess (1970). The feeling which many radiocarbon daters subscribe to, supported by Henry Polach and Jack Golson in the Australian context, is that it is premature to attempt definitive corrections of $^{14}C$ dates. Using the existing dendrochronological evidence $^{14}C$ daters can suggest the 95% confidence region, *without centroid,* which includes the uncertainties of $^{14}C$ calibration. The construction of precise graphs of radiocarbon time against calendric (dendrochronological) time from the composite data of all laboratories (including very recent and very significant contributions from Europe) awaits the results of the labours of the International Committee for Calibration of the Radiocarbon Time Scale, which was established at the 10th International Radiocarbon Conference held in Bern and Heidelberg during August 1979. This work, a complex and mammoth task, commenced in January 1979 in Tucson and continues mainly there.

## TRANSLATION OF CONVENTIONAL RADIOCARBON AGES TO TREE-RING-CALIBRATED CALENDAR YEARS

What is then a researcher to do, should he or she still desire, *at his or her own risk,* to apply dendrochronologically derived corrections? I claim that, whilst each case should be considered on its own merits, there are certain factors which must be considered in all cases. These are:

(1) Validity of $^{14}C$ age determination must be checked and sample contamination must be considered, if not actually evaluated by the dating of different organic fractions (see discussion on contamination in Polach *et al.*, 1982). Proof that the results are truly related to 95% of the activity of NBS oxalic acid (the International $^{14}C$ Dating Standard) should be sought. Such proof is best given by a series of inter-laboratory cross-checks. All results should be given as *Conventional Radiocarbon Ages BP*, i.e., corrected for isotopic fractionation and based on the Libby $^{14}C$ half-life of 5570 years. The primary data, i.e., enrichment or depletion of 'sample' activity with respect to 'standard' activity expressed on the *Delta* scale (relative millesimal difference of $^{14}C$ and $^{12}C$ ratio) or *Per Cent Modern* scale, should also be published. *Environmental* (reservoir) corrections must be applied if applicable. The code name of each originating laboratory and the number associated with each sample uniquely identifies it; they must therefore always be published.

(2) Is the researcher dealing with a single date or a series of dates relating to the same event? What is the precision of individual determinations?

A single date, irrespective of its error, should be referred to a correction table which includes all long-term changes in the $^{14}C$ inventory (any of those published are applicable). The errors in the tables should be enlarged to 95% confidence limits and the translation to a Christian calendar date should include the uncertainty of both the calibration and the individual date. The result is best expressed as an *age range* without a central figure. However, attempts to translate certain single $^{14}C$ ages to dendrochronologically calibrated Christian calendar years may be doomed to failure because different calendar years can be shown to have the same radiocarbon age. This multiple choice of calendar years thus creates a dilemma that cannot be resolved objectively if only a single radiometric determination is available.

A sequence of precise dates relating both temporally and stratigraphically to the event to be defined in calendar years is to be preferred but in itself introduces a complication; the biological age of the material to be dated needs to be considered. Thus charcoal derived from a large tree will predate charcoal derived from twigs; the determined $^{14}C$ age difference could be as large as 200 years. While the charcoal of both originated in the same fire, only the $^{14}C$ age of the twigs is closely related to the event to be dated. If this is accounted for and the precision of results (and their validity) is high, then the individual

chronologically and stratigraphically related results might possibly form an age sequency which, after assessment of biological age of material and $^{14}C$ errors, could allow the identification of a logical sequency of mutually supporting 'true' ages. To achieve this, $^{14}C$ ages must be related to a graph (not table) which most precisely defines the known short-term past variations in the concentration of atmospheric $^{14}C$.

(3) To pinpoint a precise 'true' age a researcher needs $^{14}C$ analysis of dendrochronologically determined archaeological samples and correlation of these to bristlecone pine data. While such 'floating chronology' correlations have been undertaken in the past with considerable success, it is recognised today that a unique and precise correction curve as yet does not exist. Such studies should on the one hand await the publication of Delta values, i.e., millesimal enrichment or depletion of $^{14}C$ in dendrochronological samples in relation to the standard, by the International Calibration Committee, and on the other hand be undertaken only in collaboration with a first-rate $^{14}C$ laboratory.

(4) Which of the currently available tables and curves is best? There is no simple answer as the previous paragraphs indicate. However, in principle, a long-lived sample, with accumulation of, say, $^{14}C$ activity over 20–50 years of biological life, such as is preserved in a piece of wood or large shell, should be related to smoother curves such as produced by MASCA (Ralph, Michael & Han, 1973) or Clark (1975). Short-lived material, such as twigs, leaves, grasses, single tree rings or up to 5 year segments of tree-ring sequences, should be related to the most wiggly curves, such as those produced by Suess (1970) (long-term) or Stuiver (1978) (short-term). The practice of taking available tables, calculating from each and averaging the results is inappropriate, as derived results in all likelihood would not be different from a statistical point of view, although their numerical values might differ. In all cases it should be stated which table or curve has been used, and why.

The original laboratory-derived age should be quoted, its stable carbon isotopic ratio defined, the laboratory's code reproduced and the new date suitably annotated so as not to allow confusion with the *Conventional Radiocarbon Age BP*.

(5) Are northern hemisphere-derived results applicable to the southern hemisphere? Broadly speaking, yes. Some minor discrepancies have been revealed by New Zealand $^{14}C$ daters, but reasons for them have not been clarified. There is so far no significant Australian-based research which could shed light on this problem. The most complete study is that undertaken by Carlos Lerman *et al.* (1970). It showed that tree-ring samples from continental masses in the southern hemisphere, other than Antarctica, appear about 40 years older then contemporaneous tree-ring samples from the northern hemisphere.

(6) Who should do the translation from a conventional radiocarbon age to a dendrochronologically derived calendar age? In theory anybody can. In practice, because of the increasing complexity of radiocarbon dating considerations, involving considerations of contamination, isotopic fractionation, environmental effect, standards and half-lives used, variations in age calculation and reporting procedures, questions of validity, statistics, reproducibility and international correlation and last, but not least, given the confusion brought about by the publication of a multiplicity of calibration schemes, I suggest that the interpretation should be a collaborative venture between the producer of the date and its user. I further suggest that the need for a Christian calendar correction should be recognised prior to the collection of samples and not, as so often happens, be an afterthought. Considering that variations in natural radiocarbon were recognised and confirmed as early as 1958, lack of such premeditation appears to be inexcusable. However, even armed with maximum information, the dater and user undertake a considerable risk in applying corrections in so far as accuracy of interpretation is concerned. There is as yet no unique solution to the absolute dating question.

## ACKNOWLEDGEMENTS

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# Chapter 16

# Thermoluminescence dating for the Australian archaeologist

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The technique of thermoluminescence (or TL) dating is a relative newcomer to the range of dating methods now available to the archaeologist; this is particularly so here in Australia. The potential of the technique is unquestionable, but the complexities of the method and difficulties in the understanding of the basic concepts have often led to confusion as to the true meaning of certain TL ages. This chapter will attempt to describe the principles of the method and the various complicating factors which can influence the calculation of a TL age. We shall not concern ourselves too greatly with experimental techniques but shall include information relevant to the Australian archaeologist who is considering obtaining thermoluminescence dates.

## BASIC CONCEPTS OF THE TL DATING METHOD

The basic principles of TL dating are quite simple. Most clays and soils contain minute amounts (measured in parts per million (ppm) ) of the naturally occurring radioactive series of thorium and uranium and also potassium-40. These radioactive materials are constantly emitting ionizing nuclear radiations in the form of alpha particles, beta particles and gamma radiation. When these radiations pass through matter they can cause ionization of electrons, that is, the electrons are detached, mainly via collisions with the impinging radiation, from orbit around their parent atoms. The majority of these ionized electrons immediately recombine but in certain crystalline minerals such as quartz and feldspars, a few electrons can diffuse away from the parent site and become trapped at defects, or imperfections, in the crystal lattice structure. The amount of energy then required by the electrons to escape from these trapping centres depends directly on the depth of the traps. For certain traps even the heat supplied to the electrons by ambient ground temperatures is sufficient to allow the electrons to escape. Other, deeper traps retain electrons for very long periods of time (upwards of a million years), unless the temperature of the lattice is raised significantly above ambient temperature. Of interest for dating purposes are those traps which release their electrons only when they reach a temperature in the range 300–500°C.

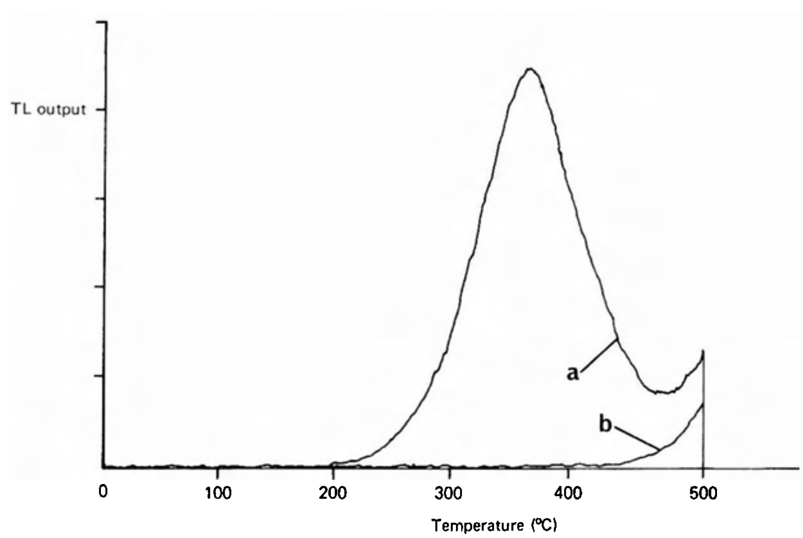
The electrons released by heating diffuse through the crystal lattice and some find luminescent centres with which they recombine and thereby give rise to the emission of light. The light emitted can be detected by a highly sensitive photomultiplier system and the light intensity versus temperature curve obtained is known as the natural TL glow curve. This is illustrated in Fig. 1. The amount of light emitted, as determined from the height of the peak in the glow curve, gives a measure of the radiation dose the material has received since it was last heated. This is because when the electrons are released from their traps by a heating process the traps are effectively left empty—an event which is said to 'set the TL clock to zero'. The material is then subjected to a small amount of ionizing radiation year by year which gradually fills the traps again until the material is analysed in the laboratory and heated once more. Thus the date obtained measures the time elapsed since the material was last heated.

In practice the natural TL output is measured from the glow curve and the sensitivity of the material to ionizing radiation assessed by giving the sample a known, artificial radiation dose from a laboratory source and measuring the resultant artificial TL output. The age of the material can then be readily calculated from the basic TL age equation:

$$\text{age} = \frac{\text{archaeological dose}}{\text{natural dose rate}}$$

The *archaeological dose* is the total radiation dose the material has received during its archaeological history and the *natural dose rate* is the rate at which this dose has been

*Fig. 1*
*The actual TL glow curve from a quartz sample. Curve* a *is the initial glow-out to 500°C and curve* b *is a second heating to 500°C after the sample has cooled giving only the background black-body radiation. The true TL response is given by curve* a *minus curve* b.



delivered to the material by trace amounts of the uranium and thorium series and by potassium-40.

The apparent simplicity of the TL age equation is quite misleading, however, because of the many complications and corrections which must be applied in each of the measurements. The following sections will attempt to outline briefly the various parameters which must be taken into account when calculating a TL age and also explain some of the terminology used by TL daters which is not immediately understandable by the archaeologist.

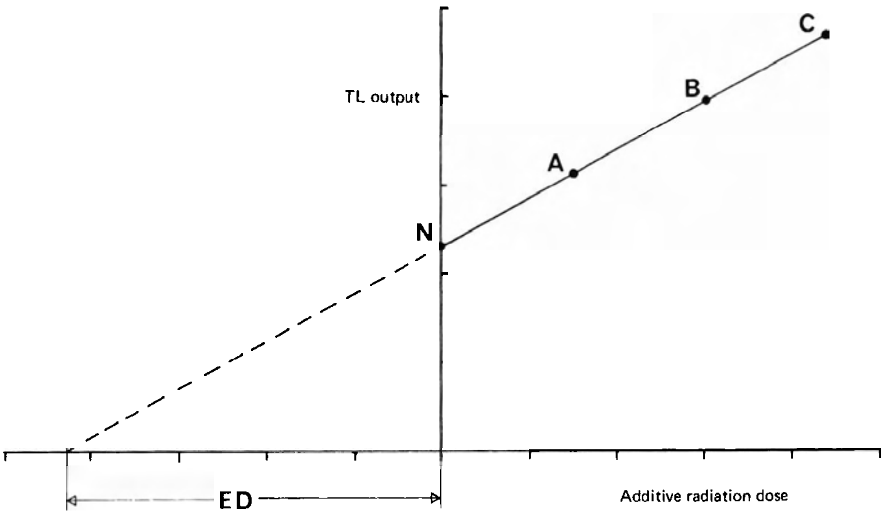
## THE ARCHAEOLOGICAL DOSE

From the time the sample was last heated in antiquity until it is glowed out in the laboratory (i.e., the glow curve is obtained by heating the sample to 500°C) it is constantly absorbing radiation from the naturally occurring radioactive series. The total absorbed dose over this period of time, the archaeological dose, is given by

$$\text{archaeological dose} = \frac{\text{natural TL}}{\text{TL sensitivity per unit dose}}$$

Unfortunately, the TL sensitivity cannot be measured by giving the same sample which has been heated to give the natural TL glow curve a second, known laboratory radiation dose and measuring the sensitivity from the artificial TL glow curve.

*Fig. 2*
*The 'additive procedure' for determining the equivalent dose, ED.* N *is the natural TL output;* A, B *and* C *are the TL output for the natural plus increasing, laboratory radiation doses.*




The reason for this is that when the sample is heated to give the natural TL sensitivity changes can occur within the crystalline material and the TL sensitivity to the artificial dose may not be the same as the sensitivity to the natural radiation dose. To overcome this problem the 'additive procedure' (Aitken & Fleming, 1972) is most commonly adopted to measure the archaeological dose.

With this procedure, several portions of the same sample are used. Some portions are glowed out to give the natural TL, *N*, whilst others are given additive laboratory radiation doses before being glowed out to give a natural plus artificial output, *A*. Different additive laboratory doses may be given to each portion giving different TL outputs, *B, C*, etc. A straight line through each of these points may be extrapolated backwards to give the intercept on the dose axis as shown in Fig. 2. This intercept is known as the equivalent dose, ED, and would be equal to the archaeological dose if the TL emission were linearly proportional to the radiation dose.

This assumption of linearity is not strictly valid, however, as departures from linear proportionality are observed at both very low doses and very high doses. In the low dose region the growth of TL with increasing radiation dose starts slowly and gradually increases until it reaches a uniform value, i.e., the linear increase with dose depicted in Fig. 2. This linear growth continues until all the traps start to become filled with electrons and saturation sets in. The low dose supralinearity, mid-range linearity and high dose saturation of the TL growth are each depicted in Fig. 3.

Saturation sets in at fairly high doses which are usually well above those received by archaeological materials. The low-dose supralinearity, however, is a more immediate problem since the linear growth region is reached only after a dose equivalent to several hundred years. The effect of neglecting the initial supralinearity when extrapolating the 'additive procedure' growth curve can be observed in Fig. 3 where *I* is the radiation dose that would not be included in the archaeological dose if a linear extrapolation only is made. To overcome this problem the *supralinearity correction, I*, is determined by giving the portions of sample which have already had their natural TL glowed out a further, known laboratory dose and glowing them out a second time. By plotting the non-linear growth of the second glow-out growth curve, a measure of the supralinearity of the natural growth curve is obtained (Fleming, 1970, 1975). The archaeological dose is given by the sum of the equivalent dose, ED, and the supralinearity correction, *I*.

## ANOMALOUS FADING AND SPURIOUS TL

There are two complicating factors which influence the measurement of the archaeological dose and these are *anomalous fading* and *spurious TL*.

Anomalous fading is a loss of TL that does not follow the principles of electron trapping discussed earlier. It was assumed that the traps which released electrons only when the sample was heated to above 300°C would be deep enough to retain the electrons with negligible probability of escape at ambient temperatures throughout the archaeological period. However, certain minerals have been found (Wintle, 1973) to exhibit a trap drainage of non-thermal origin and this phenomenon has been interpreted by Zimmerman (1977) as being due to phosphorescence qualitatively similar to the radiative recombination found in semiconductors. Fortunately, anomalous fading is not common among the minerals predominantly used for TL dating, with the most propitious of these, namely quartz, being free from the problem. For samples of unknown mineralogy, particularly those of volcanic origin, a test of the stability of artificial TL should be made over a period of several weeks. This by no means excludes the possibility of fading of the natural TL but it does appear to work in practice.

Spurious TL is the name given to the additional TL which can be induced by the rubbing together of the grains during

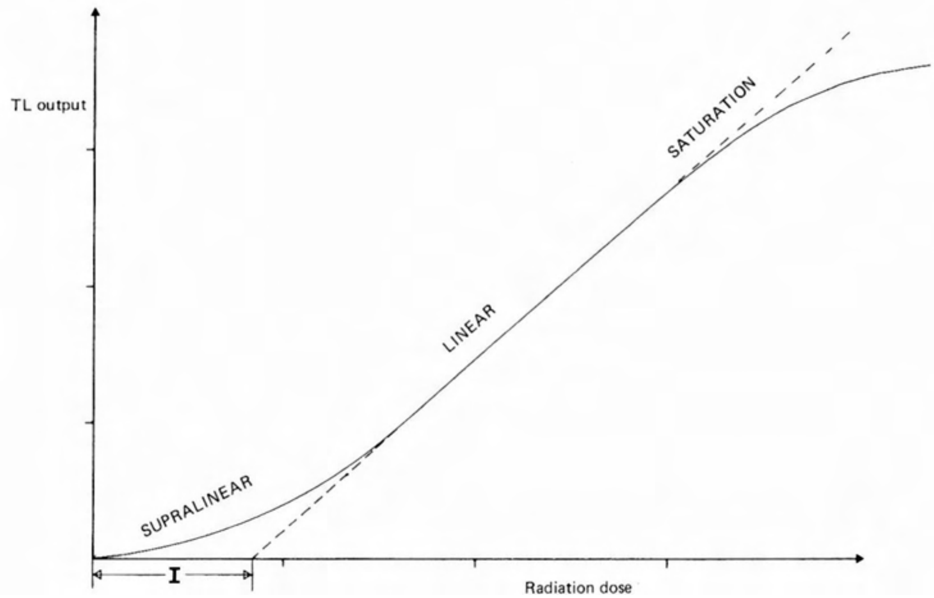



*Fig. 3*
*The growth of TL with increasing radiation dose showing the low dose supralinearity, the mid-range linearity, and the high dose saturation.*

sample preparation. This additional non-radiation-induced TL appears to be a surface-related phenomenon although its origin is still obscure. Fortunately, the effects are found to be suppressed by heating the sample during the glow out in an oxygen-free atmosphere such as high purity argon or nitrogen. The shape of the natural TL glow curves must be constantly scrutinized in order to be certain that the observed TL contains no significant spurious component. This is particularly so for samples which have a very low TL output.

## NATURAL DOSE RATE

Each of the three forms of radiation emitted by the naturally occurring radioactive series has a very different range of travel through a clay medium. For alpha particles this distance is $\sim 25\ \mu m$ ($1 \mu m$ being equivalent to $10^{-4}$ cm) whereas beta particles can travel nearly 1 mm on average. Gamma rays, in contrast, can influence material 30 cm or more away from the source, and thus a knowledge of the environmental surroundings within a sphere of radius 30 cm about the sample is necessary for any accurate dating programme. Inhomogeneities in the radioactivity within this volume can seriously affect the natural dose rate from the gamma radiation. An example of a situation where this can be problematic is the case of a piece of pottery, or sherd, buried in a soil medium. The sherd is likely to be a few centimetres in size so that the alpha and beta particles from within the sherd itself will contribute to the natural dose rate. The gamma dose the sherd received, however, will come mostly from the burial soil up to a distance of 30 cm around the sample. Hence, to fully determine the natural radiation dose received by the sherd requires an analysis of the radioactivity of both the sherd and the burial soil.

Another situation which can sometimes arise is where the sample to be dated lies in one stratigraphic layer with a certain homogeneous radioactive content but it is situated at a distance less than 30 cm from the boundary with another stratigraphic layer of significantly different radioactive content. Here again, an analysis of the radioactivity of both layers is necessary. The same effect is also created by large rocks or boulders being located within a distance of 30 cm from the sample.

## WETNESS AND RADON EMANATION

Environmental factors such as wetness and radon emanation are important even in a homogeneous context where the distribution of radioactivity is completely uniform. The presence of ground water has the effect of diluting the radiation dose and a correction factor is applicable for all samples. The magnitude of this correction factor is normally assessed by measuring the saturation water content of the material and then estimating from palaeoclimatic knowledge the fraction of this saturation level the sample has experienced during the period in question.

Halfway through the decay chain of both the uranium and thorium series there is a radioisotope of radon which is gaseous and chemically inert. A high degree of diffusion through the ground is possible before this gas radioactively decays into an immobile daughter and hence, if the soil surrounding the sample is not homogeneous in its radioactive content, then the amount of gas diffusing outwards will not be balanced by the gas diffusing inwards. This imbalance of gas movement can lead to what is known as non-equilibrium in the radioactive decay chains and, since a large percentage of the radiation dose comes from daughter products after radon, it can cause serious errors in the TL dates. Tests for possible radon emanation should always be carried out (Zimmerman, 1971) and if the problem is found to exist the necessary corrections should be applied.

Thus, environmental factors play an extremely important role in determining the TL age of any sample. This is precisely why it is vital that samples which are to be dated by TL should be excavated with the close collaboration of the laboratory which is to carry out the measurements. In most cases this will entail the presence of a TL dater during the sample collection. Just as the archaeologist is trained to find the smallest clue as to the archaeological significance of a site, so the TL dater is trained to appreciate the complexities of the environmental situation of the samples for TL dating. Only by working together can the goals of both be fully achieved.

## TL DATING TECHNIQUES

The two principal techniques used extensively for TL dating are the 'fine grain method' developed by Zimmerman (1971) and the 'quartz inclusion method' developed by Fleming (1970).

The 'fine grain method' utilises grains in the 1–8 $\mu m$ diameter size range. This size range is separated out from a suspension of the sample in acetone and it is chosen because even the short range ($\sim 25\ \mu m$) alpha particles will fully penetrate these grains. It has the disadvantage, however, of not being mineral-specific which can lead to problems such as anomalous fading, discussed earlier, which are associated with

some of the less well-behaved minerals. The 'quartz inclusion method' does not suffer from these problems because, as the name implies, it utilises only quartz inclusions of approximately 100 $\mu$m diameter. The crystalline fraction is separated from the sample by sieving and then magnetic separation (the clay fabric always has some iron impurity). The quartz grains are isolated from the crystalline fraction by dissolution of all other minerals in hydrofluoric acid. It was previously thought that this etching in hydrofluoric acid also removed a uniformly thin layer from the outside of the quartz grains. Since the alpha particles will only penetrate the outer layers of a 100 $\mu$m quartz grain it was assumed that the remainder of the grain after acid treatment would have received a radiation dose from only the beta and gamma radiation. Recently, however, it has been shown (Bell & Zimmerman, 1978) that this assumption is not strictly valid because of the extremely irregular fashion in which hydrofluoric acid attacks quartz grains. It is necessary, therefore, to take account of the possibility of a small but significant alpha contribution when assessing the natural dose rate for the quartz inclusion method.

One further technique, although still at the developmental stage but which could prove to be of extreme usefulness, is the 'zircon dating method' of Sutton & Zimmerman (1976). Zircon grains have a very high level of internal radioactivity (in contrast to quartz which is virtually radioactivity-free). Thus the dose rate to a zircon grain is predominantly due to alpha particles from the traces of the uranium and thorium series within the grain itself. This method avoids the complications associated with environmental effects such as non-homogeneity of radioactivity around the sample and the dependence on the average water content of the medium. It requires, however, a high degree of skill and expertise particularly in the separation of the grains from the clay fabric and also there is uncertainty as to the extent of anomalous fading exhibited by the mineral. When fully developed, though, this method has enormous potential particularly for samples from 'difficult' environments.

## ACCURACY AND APPLICATIONS OF TL DATING

Although the TL age equation given earlier appeared superficially quite simple we have now seen how the many corrections and influencing factors have to be taken into account before a TL date is forthcoming. Each of these complicating factors has an associated error (Aitken & Alldred, 1972; Aitken, 1976) so that for an archaeological context in which all of the TL characteristics are good, the error limit is likely to be at best about $\pm 5\%$ of the age (the errors in the ages should always be quoted at one standard deviation, i.e., the 68% level of confidence). For a site where the TL characteristics are not quite so good then $\pm 10\%$ is a more realistic figure, and for some sites it may only be possible to give an order of magnitude for the age. This point should always be borne in mind by the archaeologist when submitting samples for TL dating—the best he will obtain is 5% accuracy with the likelihood that the figure will be more like 10%.

Regarding the application of TL dating, it is necessary to consider the time span over which the method may be useful and also to which materials it may be applied. Considering the latter point first, it should be remembered that the technique of TL dating was principally developed at the Research Laboratory for Archaeology at Oxford with the primary intent of applying it to pottery samples. With the success of this application came the scrutiny of other materials as possible candidates for the method. A few of these have also proven successful such as baked clay, burnt flint and possibly unburnt calcite. Others have been more problematic such as volcanic lava, bone and burnt calcite. For the Australian archaeologist, who will probably have only a minor interest in the dating of pottery, the other successful materials listed above are likely to form the majority of the samples he submits for TL dating.

As mentioned above, the age of the material must also be taken into consideration. The two factors which restrict the age range within which materials can be dated are likely to be different for different samples. The first of these is how long the electrons will remain stable in their traps. If the regions of the glow curve around 350–400°C are used for determining the archaeological dose, then for most of the materials commonly used for TL dating it can be expected that the electrons will remain stable in their traps for a million years or more. The second factor is the saturation of the electron traps. As depicted in Fig. 3, saturation occurs when all the traps become filled. The radiation dose necessary to cause this onset of saturation depends on the TL characteristics of the mineral being studied and the age which corresponds to this radiation dose depends on the natural dose rate delivered to the mineral. For some samples saturation can occur at 5000 years, whereas others can reach 50 000 years before becoming undatable. At the other end of the time scale samples can be dated to about 100 years using a modification of the quartz inclusion method known as the 'pre-dose technique' (Fleming, 1973). This method utilises the change in TL sensitivity with dose of a peak in the glow curve of quartz occurring at 110°C. Other methods using TL as a relative, rather than absolute, technique have been applied to very old (up to several hundred thousand years) samples such as siliceous ocean sediments (Huntly & Johnson, 1976) and to volcanic rocks (May, 1977) with apparent success.

In Australia perhaps the most important applications of the technique have been the dating of baked sediments from below ancient Aboriginal fireplaces at Lake Mungo using a modification of the 'inclusion method' (Bell, 1977) and also the dating of baked ovenstones from the same Aboriginal fireplaces at Mungo by Huxtable & Aitken (1977). The results of these dating programmes place the lakeside dwellers in an era of Australian prehistory in excess of 30 000 years ago and they are of special interest because of the previous work carried out at Mungo which provided not only radiocarbon ages for the fireplaces (Barbetti & Polach, 1973) but also evidence of a geomagnetic excursion in this region at about this time (Barbetti & McElhinny, 1976). There is reasonably good agreement between the TL and radiocarbon dates for the Mungo fireplaces but a small discrepancy does exist with the TL ages consistently about 10–15% older than the radiocarbon ages. This difference, if real, can be explained in terms of variations in the Earth's geomagnetic field which in turn affects the C-14 production rate and hence the C-14 age.

One further application of the TL method in the Australian region was the dating of cooking stones from archaeological sites at the Kuk Tea Research Station in the highlands of New Guinea (Bell, 1976). These stones were predominantly of the metavolcanic type and their use was expected to be less than 300 years before present. The 'pre-dose technique' of Fleming (1973), mentioned earlier, was applied to these samples but the quartz extracts from the stones were found to have a high degree of impurity diffusion which resulted in large uncertainties in the TL ages. Nevertheless, all of the ages fell between 100 and 300 years, which is consistent with the archaeological evidence.

## CONCLUSIONS

This chapter explains some of the complicating aspects of TL dating. It also provides a guide to the kind of information required by a TL laboratory in order to produce a date. The most important is information about the environmental situation of the samples such as the presence of nearby rocks, boulders or different stratigraphic layers. In addition, palaeoclimatic information relating to the archaeological period of the samples is needed, and it has been stressed that even before a site is excavated the TL laboratory to which the samples are to be submitted should be consulted and that a TL dater should be present when the excavation is taking place. Different laboratories have different approaches to the excavation of samples but there are three important requirements which are common to all once the samples have been collected.

(1) The sample must not be heated above 100°C as this would cause the release of electrons from their traps.

(2) The sample must not be exposed to any form of ionizing radiation such as ultraviolet, infra-red, X-rays, gamma rays and beta particles.

(3) The sample should not be exposed unnecessarily to direct sunlight as this usually contains a high level of ultraviolet radiation.

Any other requirements will be specific to the particular dating project and to the laboratory concerned and hence the importance of close interdisciplinary collaboration between the TL dater and the archaeologist. Discussion of projects with the TL laboratory and the presence of a TL expert during the excavation of samples are both areas in which such collaboration is extremely desirable if not essential. Only through mutual discussions can come a full understanding of a meaning of certain TL dates and of their archaeological significance.

The number of TL laboratories in the world is not great but it is increasing slowly. The main centres at present are located at Oxford University in England, Washington University, St Louis, in the USA, and at Risø in Denmark. In Australia, the Australian National University laboratory was the first to be established but others are now being set up in both Sydney and Adelaide, and it is to be hoped that they will soon become fully operational.

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*Note:* Chapter submitted in 1978.

# Chapter 17

# Stone artefacts—an illustrator's primer

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There are three basic steps to be followed when drawing stone artefacts for publication. Publication is understood to be anything that is destined for circulation—from seminar paper to thesis to prestigious journal.

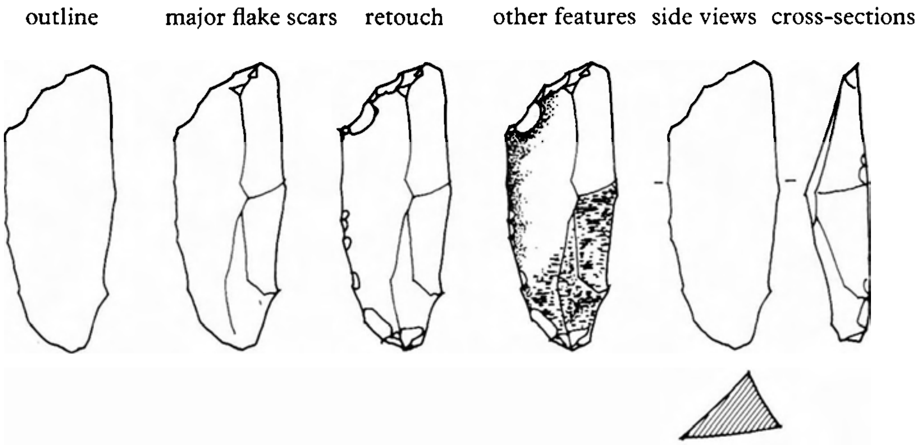
(1) Preliminary or working drawing in pencil.

(2) Page layout.

(3) Final drawing in ink.

## PRELIMINARY OR WORKING DRAWING IN PENCIL

The drawing should be constructed in the following sequence:




### Outline

*Drawing from photographs*

The fastest way to draw an artefact is to trace it from a photograph. No photograph will show all the details of flaking and retouch but it is at least possible to get a very accurate outline and a framework within which the retouch can be sketched.

A couple of quick snaps of half a dozen artefacts will not do.

- Each artefact must be photographed separately.
- Light must come from all around to eliminate shadows.
- A scale must be included. If the artefact is more than a centimetre or two thick the scale must be supported so that it is at the same level as the edge of the artefact. It is the outline that is important and it must be at the correct scale.
- Take care that the artefact is not tilted. If necessary, prop it up with some plasticine so that it lies flat.
- Chunky artefacts, where edge retouch is not visible from the top, will have to have end or side views as well.

When prints are made, ensure that the scale is at natural size, unless:

- The artefact is very small and could be more easily drawn at an enlarged size.
- The artefact is very large and might better be drawn smaller.

Some material, quartz, for example, does not photograph well. To overcome this:

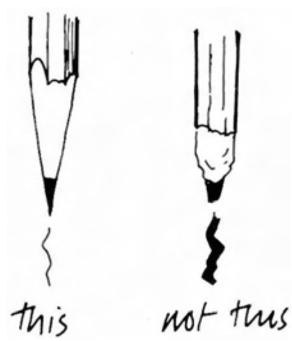
- Rub the flake lines with the flat edge of a pencil to emphasise them, or
- Paint the artefact with a thin coating of white tempera powder mixed with water (it will wash off).
- Paint the artefact and mark with pencil.

Tape a piece of tracing paper to the photograph and draw the artefact in the sequence suggested in the following section. A photograph alone is not enough to draw from—you must have the artefact itself as well to refer to constantly.

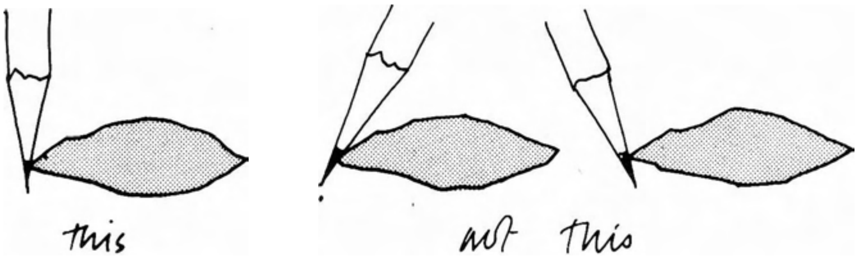
*Drawing directly from the artefact*

In the event that photographs are not available, as is most often the case, the artefact will have to be constructed by measurement.

- Place the artefact on a piece of paper (tracing, typing or whatever is readily and cheaply available—remember that this is a preliminary drawing, not a final one).
- Hold the artefact firmly with one or two fingers.
- Trace around the artefact with a sharp and long pointed pencil. I do mean sharp and long.
- Use pencil of H grade, that is, H, 2H or 4H. HB and other B leads are too soft and quickly become blunt and smudgy.

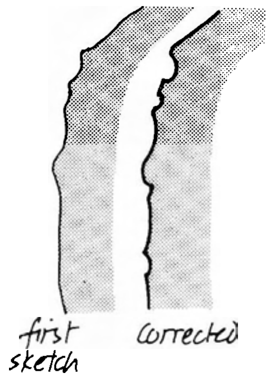


- Take care to hold the pencil upright otherwise inaccuracies start to creep in.

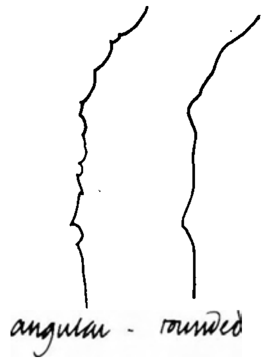



When the outline is complete remove the artefact and check that the drawing looks like the original. There will inevitably be differences and they must be corrected at once, otherwise errors will be compounded as the drawing progresses. If the outline is distorted there is little hope of making other detail fit. Check and check again with measurements taken with calipers.

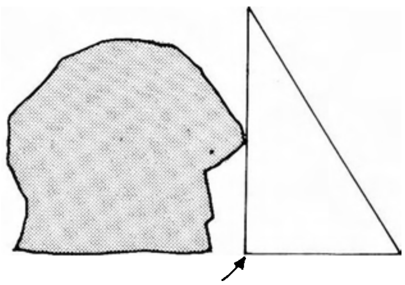
- Indentations will be smaller than they ought and bumps bigger. Correct them.




- Make lines angular rather than rounded.



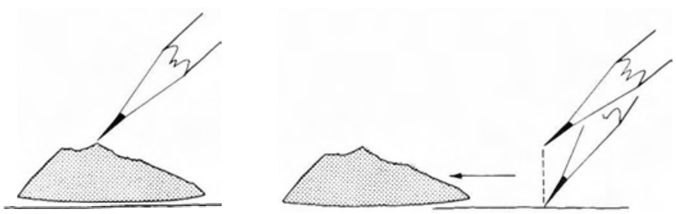

Block artefacts, especially horsehoof cores with overhanging edges, present another problem. The outline as seen from above, which is the one you are concerned with, is not the same as the outline at the base. Move a set square around the tool and mark with pencil the path followed at the base of the set square.

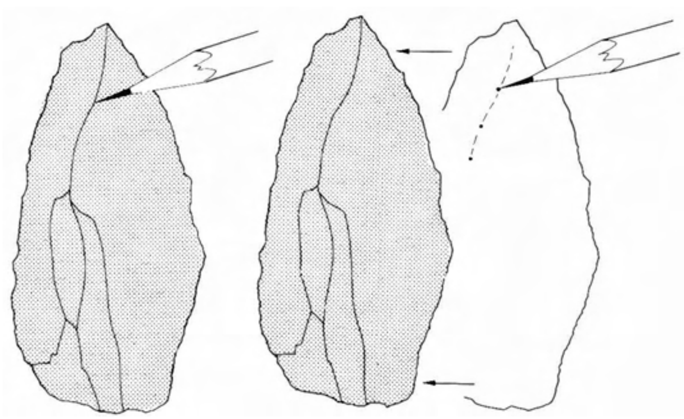


- If an artefact will not sit flat it can be supported by a piece of plasticine. Plasticine will leave a greasy spot so use it sparingly.

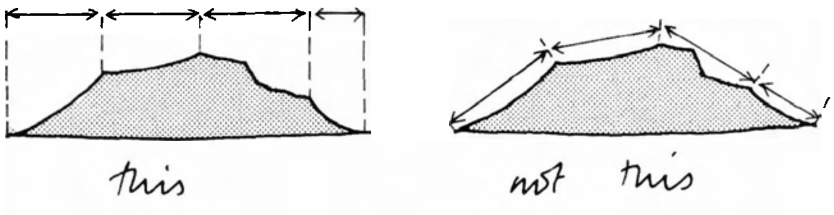
**Major flake scars**

Place the artefact over its drawn outline. Hold a pencil point on a flake line. Keep the pencil steady, slide the artefact away, then lower the pencil point on to the drawing below. Repeat this until there are enough points on the paper for the flake lines to be drawn in fully.



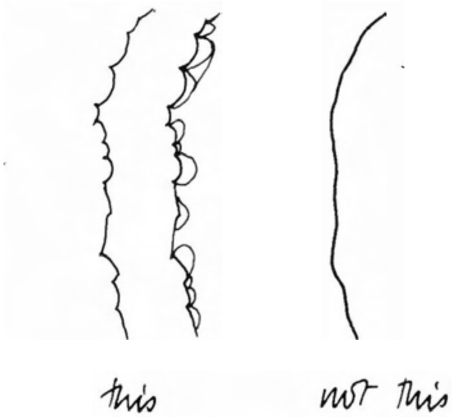


The positions of the flakes can be measured with dividers or calipers. Remember that you are drawing a plan of an artefact, therefore all measurements must be made on a horizontal plane.

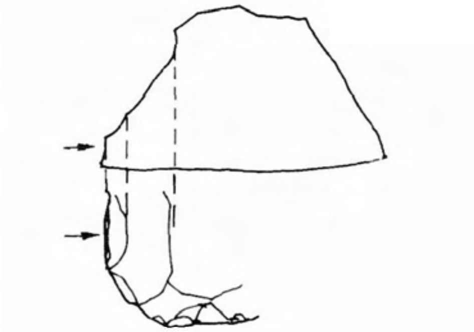



## Retouch

This will have to be sketched in by a combination of the two preceding methods and a lot of fiddling. If the outline of the artefact has been properly drawn, much of the edge retouch will be self evident.

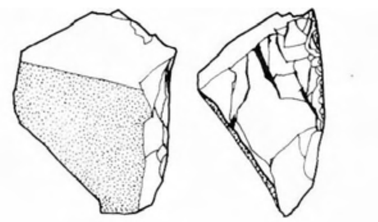



On steep edge artefacts there will have to be some exaggeration to show retouch at all. Although the flake may measure some millimetres up the face of the artefact, its horizontal distance will be little more than the thickness of a line. Take care not to overdo it, though. On a very steep edge little or no retouch can be seen from a top or plan view. In such a case a side or end view will have to be drawn.

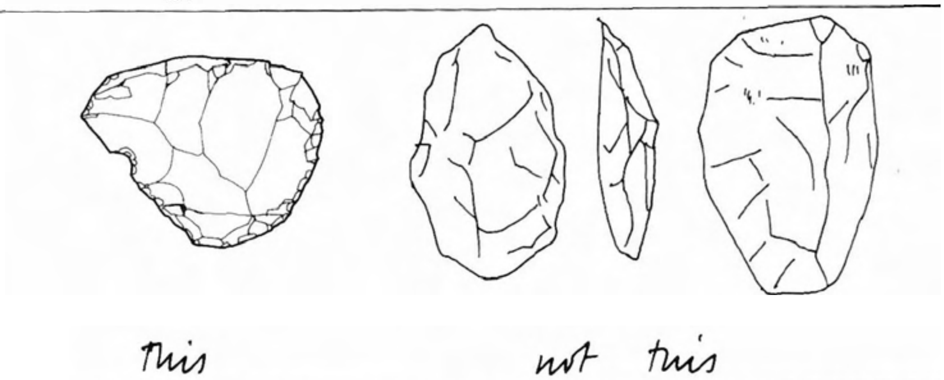


It is really very hard to get the shapes of flake and retouch lines to look right on a drawing. The basic problem is one of transposing a three-dimensional object on to a single plane. If you feel confused by it all, put the drawing away and try again another time. A fresh start does help.

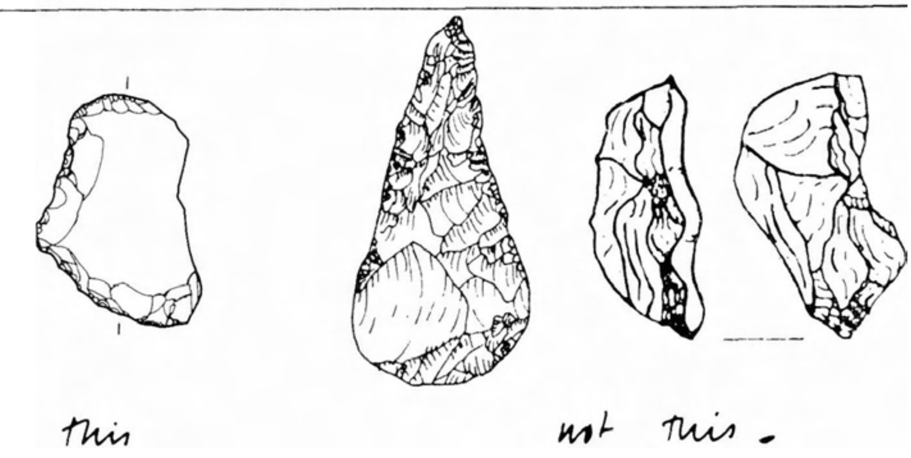
The edges of the flakes are sharp lines. They flow smoothly and must be shown to do so. Irregularities should be ignored if they are small and played down otherwise.



Do not leave flake or retouch edges incomplete. If you cannot decide where each starts and ends then either dot it in or do not show it at all.




Try to avoid an excess of detail. A drawing is merely a plan of an artefact, an interpretation, and the simpler it appears to be the easier it is to comprehend. A few decisive lines give a clearer impression than a fussy, embellished version where the essential form is obscured by a mass of detail.



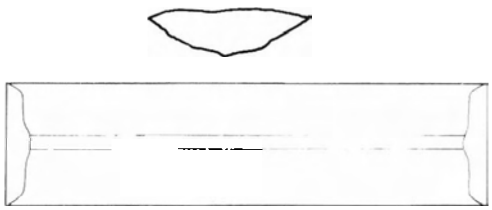
### Other features

These, for example use polish, cortex and gum, should have their boundaries marked and be identified.

### Side views

Backed blades, elouras, steep edge scrapers, horsehoof cores and chunky artefacts in general, need a side view to show properly the form of the artefact where this is not apparent from the plan alone. With the aid of a photograph a side view can be drawn quickly and accurately. Without one, the view will have to be constructed as the plan was, by measurement. The outline can be drawn with the help of a template former.

A template former consists of a lot of needles held together in a frame. When the needles are pressed down on an artefact they take its shape. The profile thus obtained becomes the outline of the side view. The shortness of the needles limits the template's reach so a thick artefact may need several profiles which then have to be matched together. Keep checking for accuracy with calipers. Flake and retouch can be drawn in as usual.

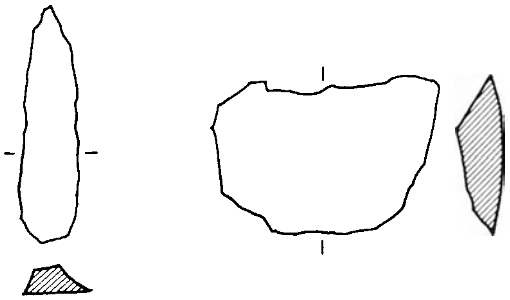





- It is customary for a side view to be drawn alongside that part of the artefact from which it was taken.
- If you choose not to observe this convention you must show very clearly where the view belongs.

### Cross-sections

Cross-sections are also used to show the form and thickness of an artefact. They may be used in addition to, but not instead of, a side view. They also can be constructed with the aid of a template former and calipers. When drawn, they should lie parallel to the axis along which they were taken. Draw two small identifying marks outside the artefact plan to show the line of that axis.



## PAGE LAYOUT

A lot of time will have been spent constructing the working drawings. Do not just slap them together in the belief that they will somehow look alright. They will not. A thoughtful presentation will enhance the drawings, a careless one will detract from them. A page of illustrations must invite attention, not fill the reader with dismay or, worse, disinterest. A moderate amount of reduction does flatter drawings. Do not be deluded into thinking that reduction is the cure-all for bad drawing. It is not, but it can lessen the impact by making blemishes less apparent. It is also possible to squeeze a few more drawings on to a page when it is larger than the final text size. Although the drawings are at natural size there is no need for them to be published at that scale.

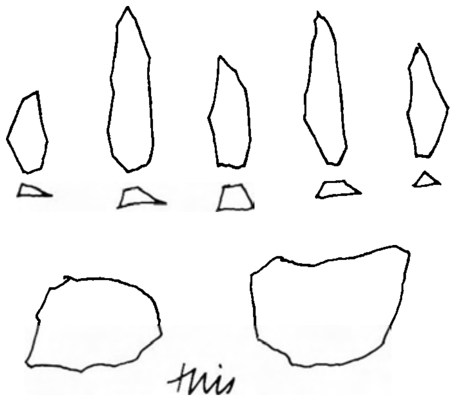
Before deciding to arrange drawings for reduction make sure that facilities for reducing copy are available. Unless you have access to a photographic service or a copying machine that will reduce, or are contributing to a journal that will do it anyway, the drawings will have to be produced at the size at which they will finally appear.

If reductions cannot be made:

- Take a piece of squared paper.
- Draw a rectangle exactly the size of the text area of your publication.
- Arrange the working drawings within this frame.

If reductions can be made:

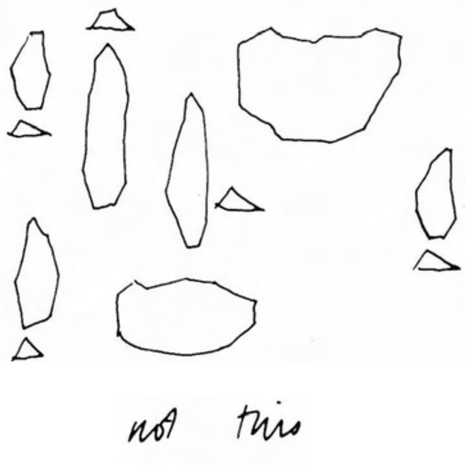
- Take a piece of squared paper.
- Draw a rectangle the size of the text area.
- Enlarge this by half again. For example, a text area measuring 15 cm by 20 cm will increase to 22.5 cm by 30 cm. It need not be as much, or it can be more, but it must be in the same proportions as the text area.
- Do not draw at a size greater than twice the text area.
- Arrange the working drawings within the frame.




### Arrangement of drawings

Artefacts should be grouped in an orderly sequence. Try always to consider your reader. While you are familiar with the artefactual assemblage and know what you are trying to show, the reader does not. Faced with a jumble of artefacts he or she will not be motivated to look at them and your efforts will have been in vain.

- Look at existing publications and model your layouts on those you find attractive.
- If there are only a few artefacts do not space the drawings out to fill a whole page. Fit them into half a page.
- Move the drawings around within the frame until a satisfactory arrangement has been found.
- Tape them down.
- Place a fresh sheet of tracing paper over the drawings and tape it so that it will not shift.




## FINAL DRAWING IN INK

Final drawings must be made in black ink. Any other sort will not copy properly. Make sure that the lines really are black and dense. Hold a sample up to the light. If the lines seem grey or broken and light is showing through them you must try again.

### Drawing pens and materials

Try to get a copy of an excellent booklet published by Staedtler titled *Guide to the correct selection and use of material for technical drawing.* It is free and should be available from graphic art suppliers. It covers in detail the use and care of drawing pens and pencils.

*Pens*

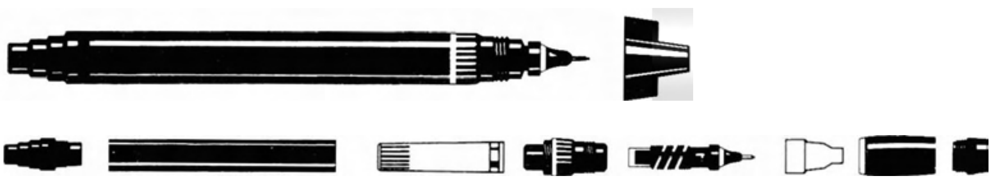
You should have a basic set of three tubular tipped pens for drawing. There are a number of makes available but as they all work on the same principle your choice will be governed by their cost. They are easy to use and, although expensive, will last a long time if cleaned often enough. You will need a minimum of three pens. There are two numbering systems for line widths:

(a) The traditional, where 0.2, 0.3 and 0.4 are the sizes you will need.

(b) The ISO range where comparable sizes are 0.25, 0.35 and 0.5.

*Paper*

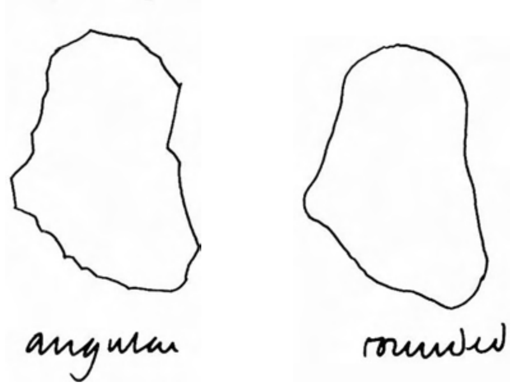
- Tracing papers are relatively cheap. Choose a heavy grade, for lightweight paper absorbs moisture from sweaty hands and crinkles easily. Heavy ones will too, but less readily. Mistakes and blobs can be removed with a fibreglass or special ink eraser.
- Plastic drawing films are easy to draw on but expensive to buy. Mistakes can be scratched off with a scalpel blade but the surface, once damaged, will not accept ink well. Provided an etching ink is not used unwanted lines can be removed with water.
- Drawing paper. If you want to use paper choose one that has a smooth, untextured surface. An uneven surface will break up ink lines, making copying difficult.



### Drawing

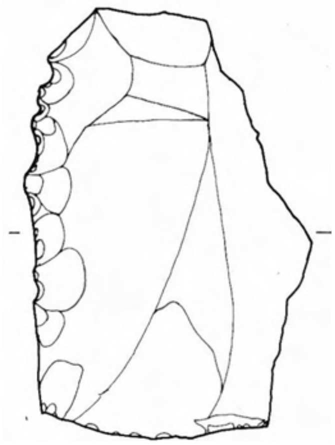
*The outline*

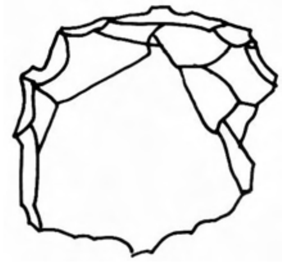
If the drawings are to be reduced use a 0.4 (ISO 0.5) pen; if not, a 0.3 (0.35). Make shapes angular, not rounded.



*Flake scars and retouch*

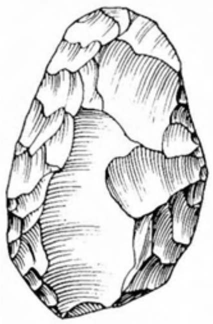
Use a thin line, 0.2 (0.25) to make a contrast with the thick outline. This contrast in line widths gives the drawing a certain crispness. If the same line widths are used for both inner and outer lines the appearance is one of rather dreary uniformity.



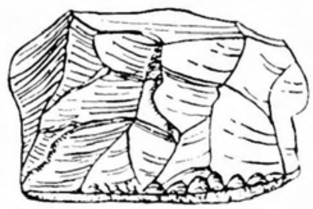


Many illustrators feel the need to show the direction from which flake scars have been struck and the contours of the artefact. The convention looks like this:

When well done it looks superb but badly done, as is more often the case, it is quite awful. So do not try.



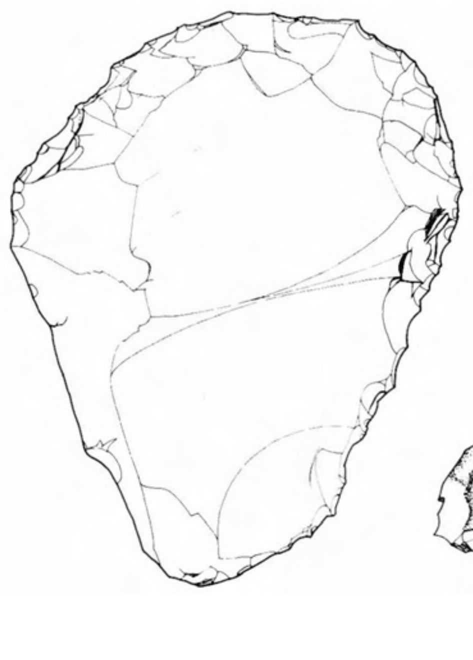




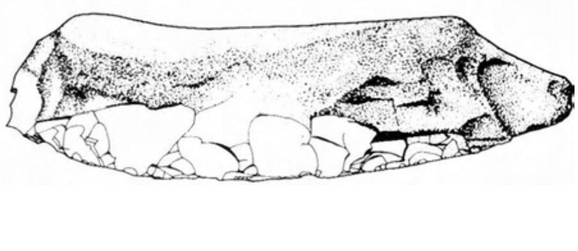


If the outlines of the scars have been precisely drawn, the direction of flaking will be self-evident. You have started with a simple drawing; clutter it up and clarity will be lost. Remember, all the time, to understate, not overstate.

Practice, by all means, but do not publish until you can achieve this:



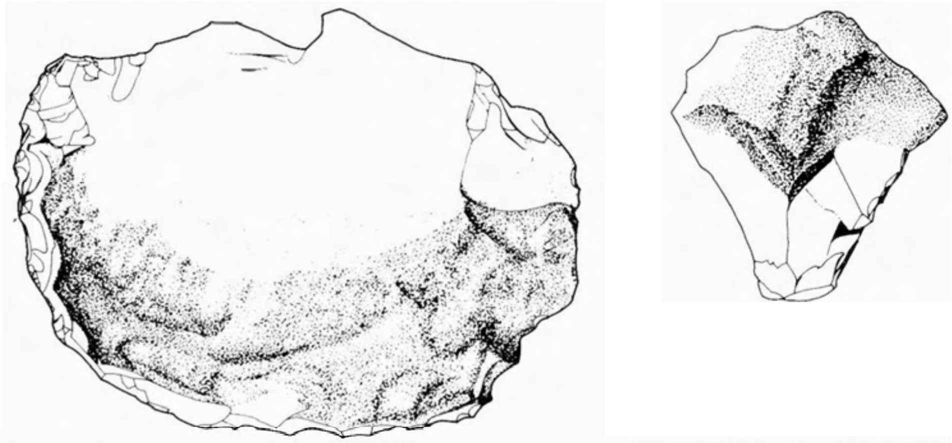






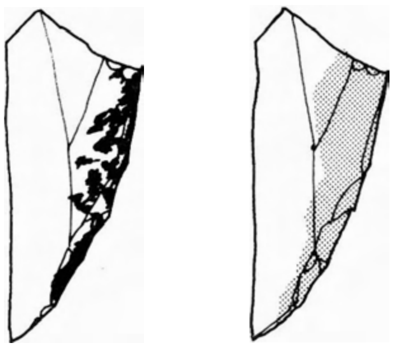
*Cortex*

This is usually shown by stippling (dotting). By decreasing the amount of white space between the dots, or, if you like, putting more dots closer together, it is possible to give the impression of an irregular surface.



*Gum*

This can be shown solid black unless there is a lot, in which case it ought to be stippled. The dots ought to make an even pattern.



*Use polish*

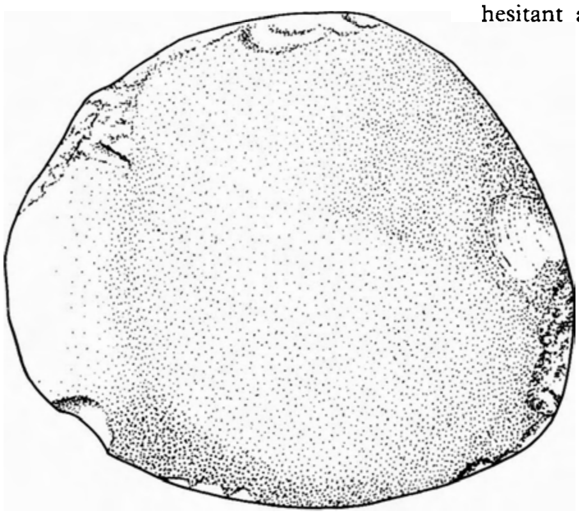
This can also be shown by stippling.



If you have the misfortune to be drawing an artefact that has cortex, gum and use polish on it then you will have to exercise some ingenuity to make the patterns of stippling show three different things. Make sure that the reader can identify each type. You know what each is, but he or she will not, unless it is made quite clear.

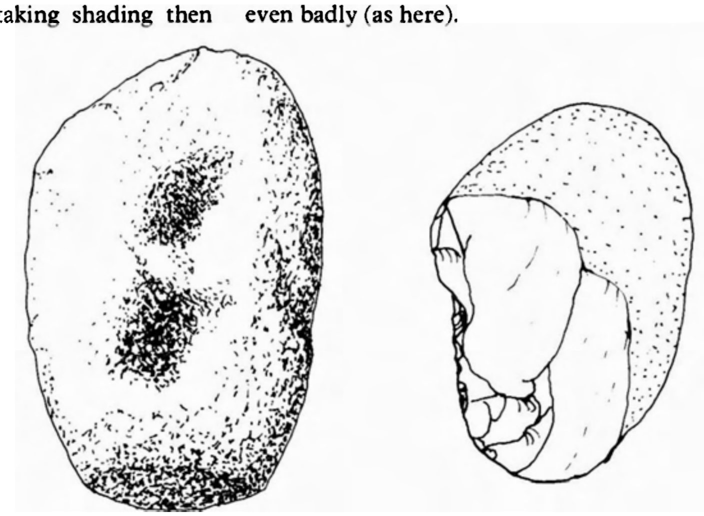
*Polished or ground tools*

Stipple these.

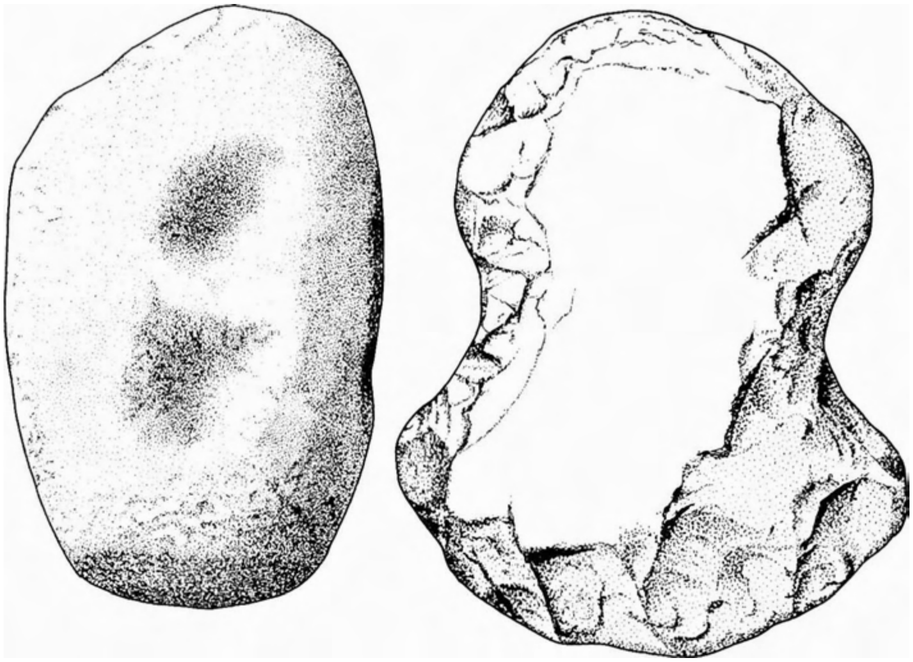


*Hammerstones, pebble choppers, etc.*

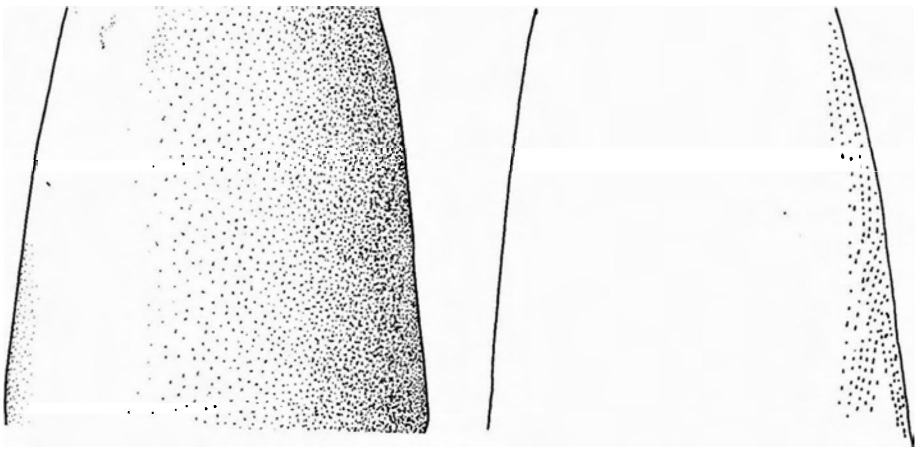
Most of this group have smooth, rounded surfaces. These can be shaded with stippling to show roundness. If you feel hesitant about undertaking shading then play safe and do not attempt it. It is not, after all, vital to an understanding of the artefact. Shading takes a lot of time to do, even badly (as here).



If you do want to, then observe the convention that an imaginary light source comes from the top left hand corner. The deeply shaded areas will be those on the right and lower right hand parts of the artefact.



Be careful how the dots are put on. They must be evenly spaced, with the density increasing gradually. Avoid lines or rows of dots.

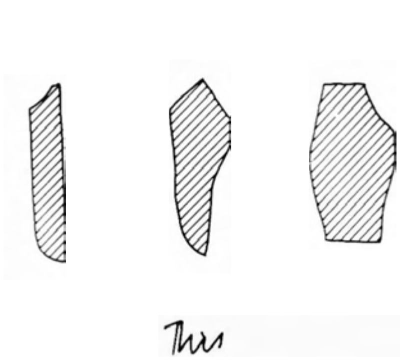


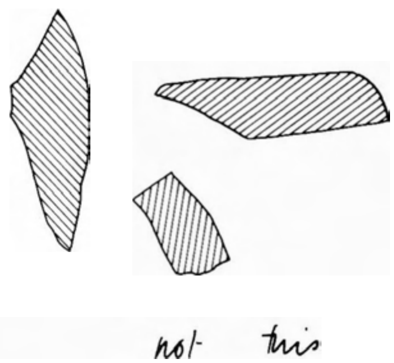
*Cross-sections*

Can be left blank, or filled in with cross-hatching.

Make sure that all the cross-hatching lies in the same direction.

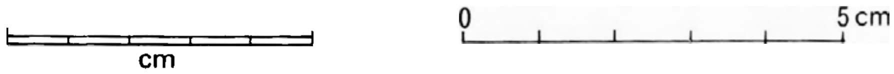
Do not make the sections all black. Blocks of solid colour give too much emphasis to the section at the expense of the artefact itself. Large areas of ink on tracing paper will make it crinkle just as it does when coffee is spilled on it. Crumpled drawings make editors exceedingly peevish.



*Scales*

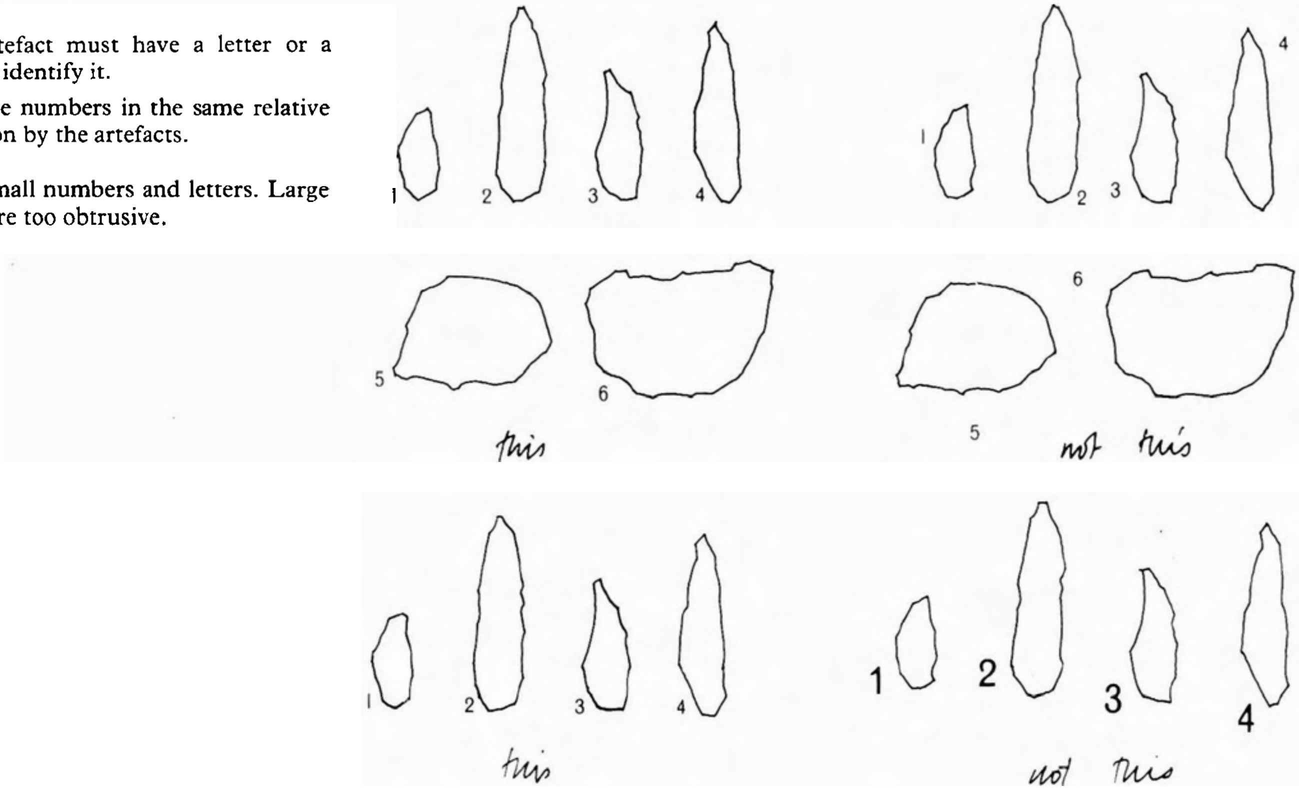
Never give a written description of a scale, for example, 'artefacts are at 1 : 1'; or '2 : 1', or 'natural size', or 'half natural size'. There is no guarantee that when they are published they will be at the size you meant them to be. Always draw a simple line scale.




*Labelling*

Each artefact must have a letter or a number to identify it.

- Put the numbers in the same relative position by the artefacts.
- Use small numbers and letters. Large ones are too obtrusive.




## Obtaining equipment and materials

Look around your graphic art supply shop; you will find a huge range of drawing aids available. Do not get too carried away. Acquire this basic kit and then expand if you will.

*Pens*

Tubular tipped. There are a great many brands on the market. Choose according to the state of your pocket.

*Cleaning fluid for pens*

Water will do nicely if you are diligent about keeping pens washed often. If you are not, buy a bottle of a proprietary brand of cleaning fluid for your sort of pen.

*Ink*

Black drawing ink, but only one of those specifically for tubular tipped pens. Any other will clog the pen and probably ruin it, forcing you to go and buy a new pen as well as more ink.

*Pencils*

H, 2H, or 4H; any brand.

*Erasers*

Fibreglass or ink eraser for tracing paper; scalpel for drafting film; something soft for paper.

*Drafting media*

Tracing paper, medium to heavy weight with a smooth surface. Drafting film, plastic or polyester. Drawing paper, make sure that it is actually for drawing on. Some cards look lovely but are not suitable for ink. Choose a white rather than a cream one, and one that has a smooth surface.

*Calipers or dividers*

*Template former*

*Graph paper*

*Graphic aids*

Dry transfer lettering (Letraset or Formatt) for numbers and letters. Patterned film for lines for cross-hatching, or dots for some stipples.

*Note:* Chapter submitted in 1980.

# Chapter 18

# A gadget to help in drawing small finds

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Drawing small finds from archaeological contexts is a difficult and time-consuming task. Over the years there have been many attempts to make the task easier. Some of them have involved highly sophisticated equipment such as optical pantographs. Generally these have had the disadvantages that they were both expensive and difficult to obtain or construct. The gadget described in this chapter does not have such disadvantages, being both inexpensive and simple to construct. It is, in fact, a do-it-yourself gadget.

## FUNCTION

This gadget is designed to project a life-sized picture of a small find directly on to a piece of paper on which the drawing is made. As the object and the drawing are both at the same distance from the drawer's eyes, there need be no problem over scale, parallax, or focussing.

## THE PRINCIPLE (Fig. 1)

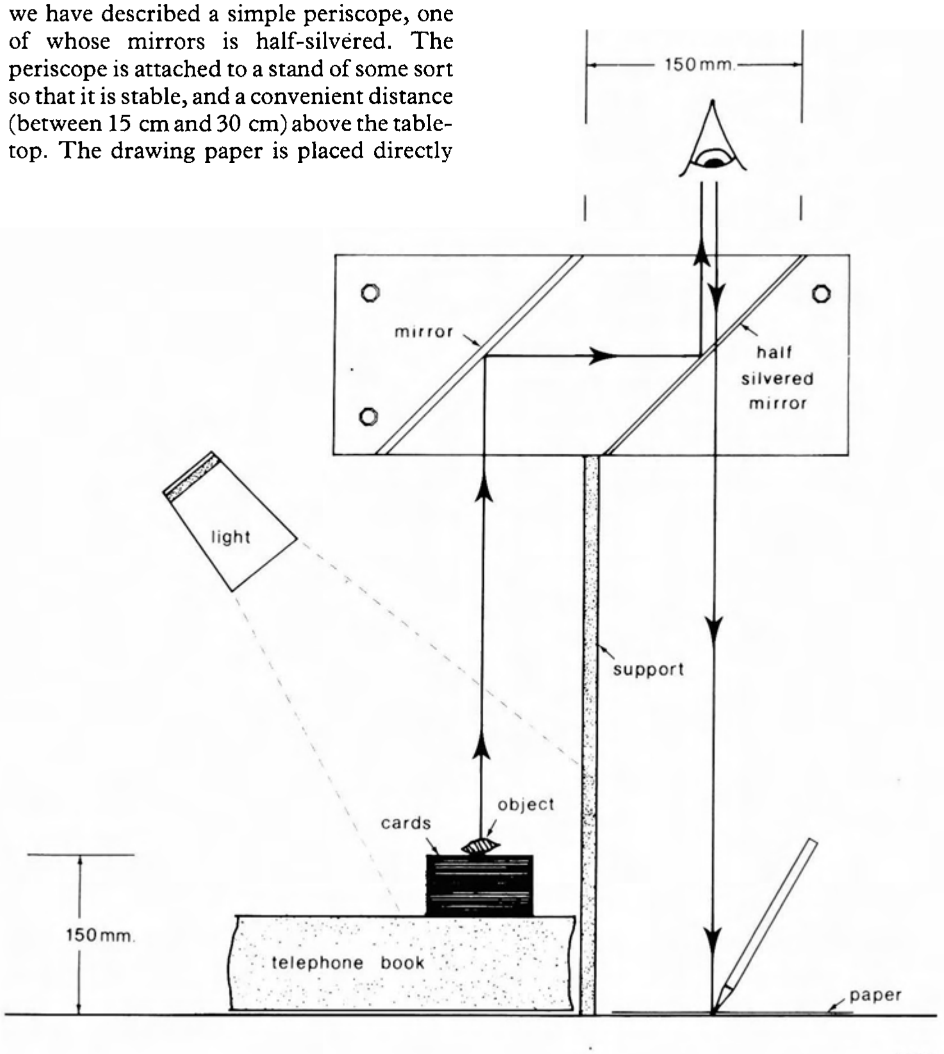
A half-silvered mirror permits the simultaneous reflection of one image and the passage of another. The paper upon which the find is to be drawn is seen directly through the half-silvered mirror. Half-silvering consists of laying onto a piece of glass sufficient reflective substance to allow of some reflection while permitting also the transmission of light. Many city buildings nowadays have windows treated with a plastic sheet which has the effect of reflecting some of the incident sunlight, thus cutting down on heat transmission while allowing sufficient light to enter for illumination purposes. Some glaziers offer the service of re-silvering mirrors; such people can half-silver a piece of glass.

The find is reflected to the artist by a normal mirror, and reflected a second time by the half-silvered one. Both images are the same, correct, way round. One is seen direct, the other has been twice reflected. On looking through the gadget, the find is seen imposed upon the paper where the drawing is to be made.

## THE DEVICE (Fig. 2)

The gadget consists of two mirrors, one wholly silvered, the other half-silvered. They are set parallel, 15 cm apart, at an angle of 45 degrees to the vertical. The setting may be made of any suitable material, the first versions of the gadget used grooved wood joined with bolts. So far we have described a simple periscope, one of whose mirrors is half-silvered. The periscope is attached to a stand of some sort so that it is stable, and a convenient distance (between 15 cm and 30 cm) above the table-top. The drawing paper is placed directly below the half-silvered mirror. The small find to be drawn is placed on an adjustable stand 15 cm above the table-top, and directly below the normal mirror. The distance apart of the mirrors and the height of the stand given here are not critical, but a matter of convenience. It is crucial, however, that the distance between mirrors

*Fig. 1*
*The principle of the gadget.*



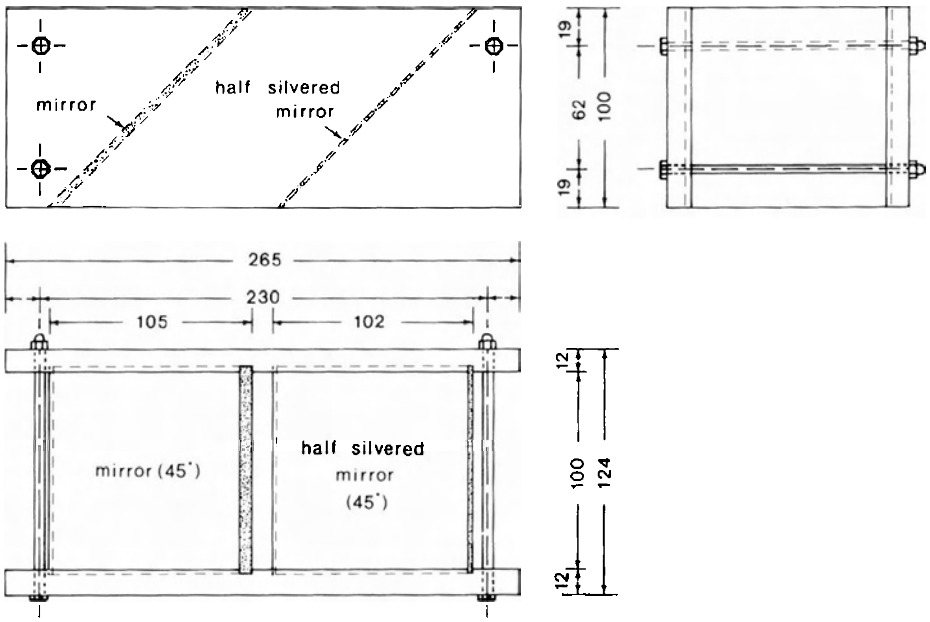



*Fig. 2*
*The design of the gadget.*



*Fig. 3*
*The gadget in use.*

be the same as the height of the stand—this is what makes the images in focus.

The easiest way to make an adjustable stand is to place a stack of filing cards on top of a thick telephone book. Very fine focussing adjustments may be made by adding cards to the pile beneath the small find, or taking them away.

An adjustable spotlight is essential for illumination. It is important to get the right illumination balance on paper and find, or one of them will be invisible.

## OPERATION (Fig. 3)

(1) Place paper in position, beneath the half-silvered mirror.

(2) Take one small silver and one small copper coin, place the copper one on the drawing paper, the silver one on the small-finds stand.

(3) Adjust the lighting until both coins are visible when looking down through the half-silvered mirror to the drawing paper.

(4) Move one of the coins until it appears right on top of the other.

(5) It will be noticed either that both coins are at the same apparent distance—when both will be in focus, and they both appear to move together if the observer's head is moved—or that they are at different apparent distances. The level of the stand must be adjusted till they both appear to be at the same distance.

(6) Remove the coins, position the first small find to be drawn. It may need plasticine or some other substance to orient it properly. Make a mark on the paper with a pencil, marking the place of some small feature of the find. Test for focus. Readjust the focus. The focus will need adjusting for each thickness of object. The adjustment makes no difference to the size of the image—which is always the same as the object.

(7) Continue to draw the object in pencil till satisfied, and then the drawing is ready for the next stage, that of inking it in.

## COST

At the time of writing (1978), the cost of materials to construct this gadget was approximately $5.

*Note:* Chapter submitted in 1980.

# Chapter 19

# Report writing and publication

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> I am informed that there are people who think they are doing good by digging and grubbing out antiquities, without making any record at all of their investigations. I think that a landowner, if he is not sufficiently interested in these matters to work himself, could do no better service to Archaeology, than by prohibiting the investigations of any one, without obtaining some security that they will be well recorded. A discovery dates only from the time of the record of it, and not from the time of its being found in the soil. (Pitt Rivers *Excavations at Cranborne Chase . . .*, 1898, p. 28.)

Just before starting to write this chapter I completed a report on some stone axes collected in the New Guinea Highlands by a student who was killed in a car crash. I had the axes, his field notebooks and laboratory work sheets, and was able to discuss the research with the assistant who was in the field with him for the entire time. The report I produced is, however, a mere shadow of the one he would have written. I did not know his major aims in making the collection, his notes were notes rather than carefully worked-out manuscripts, some of the axes were unlabelled, and the purpose of some of the analyses he had begun was unclear. What I had to work on, in fact, was the ordinary residue of a junior scientist at work, one whose activities were no more and no less organised than our own. Had he lived, order would have been drawn from this material, and some further prehistory written. All that I could do was systematise the remnants so that I and others may perhaps be able to draw on them for other purposes.

I tell this story, not because I expect most of us will have our careers cut short, but to underline Pitt Rivers' trenchant point: what you have found and thought is irrelevant and useless until it is recorded in a way other people can understand. Research which is not available for others to use does not exist. The hard work, time and money which went into the fieldwork and analysis have been wasted. Part of our heritage from the past, along with some present resources, have been destroyed as totally and uselessly as if they had been dynamited or bulldozed over a cliff.

If you do not write it down it does not exist. The converse is also true: what you report and publish is all that exists. If only the shells or skeletons in a site are reported on, that is all that site will ever tell us about. What is thrown away in the search for skeletons or shells is no longer evidence, and might as well never have existed.

Archaeologists have obligations in two directions. First, as scientists, our research must be directed towards problems: without this, we become mindless collectors of prehistoric (and historic) garbage. But secondly, as destroyers of the past, we have an obligation to record what we destroy in the course of our scientific research: otherwise, we can destroy great segments of prehistory in the selfish pursuit of our particular ends. These two obligations, taken at their absolute value, are often in conflict, and no easy solution is apparent. Both must be constantly recognised, and each one of us can only try to pay our dues to both. It is not easy.

The obligation of every archaeologist—and I include here every student and idle collector of artefacts—to report his or her activities is clear. I shall now provide some guidelines on how best to go about the business. First, there are some general aspects of report writing to consider, next some particular requirements of archaeological reports and finally some basic necessities in writing for publication.

## REPORT WRITING: GENERAL

The writer of an archaeological report faces many problems no different from those of any other scientific or technical writer. There are several books on report writing available which discuss these problems, sometimes in minute detail. I recommend especially Trelease (1969), Woodford (1968), O'Connor & Woodford (1975) and Royal Society (1974) as being clear and detailed but not fussy or puerile. Without repeating most of their good advice, I draw your attention to six crucial aspects of authoring.

(1) The reason for writing a report is so that people may read it. But which people? *Who* are your intended readers? *Write for them.*

A PhD thesis, for example, is expected to be a piece of original research on a specific problem, written about in such a fashion as to convince examiners and other scholars of your expertise in a particular discipline. An environmental impact statement, on the other hand, must contain some sections written for non-archaeologists, so that planners and decision makers can understand and apply your recommendations. An account of the prehistory of an area (e.g., a national park) for use by the public, should be written in everyday English and should use technical terms only if absolutely necessary. A decision as to your intended readership must be the *first* conscious step in report writing, since it will determine both the content of the report and the style you write it in.

(2) Reports should be precise, logical, brief and in plain English. The name of the game is *communication.* This applies both to the overall structure of the report and to individual sentences and paragraphs within it.

(a) Structurally, any report can be written in four main sections. These are:
*Aims:* What is this paper going to tell us about? How does this fit in to any larger project or area of theoretical debate?
*Methods:* How (and where) did you go about your investigations?
*Results:* What did you find?
*Feedback:* What recommendations can you now make? Where do we go from here?

Try to organise your material into these four broad sections first, and make any

modifications later. This format is basic because it clearly separates thoughts from actions, and discoveries from deductions. As Sir Mortimer Wheeler says: 'Plain and effective writing implies a plain and effective structure' (1956: 215).

(b) Each paragraph and sentence should be straightforward in itself and follow from the preceding one. It is at the sentence level that most difficulties of expression occur, as is shown by the following examples:

> One clue [to the disappearance of Neanderthal people] is that they lived chiefly during hard winters when death rates must have been high (Pfeiffer, 1969: 194).

This sentence is simply expressed and in direct language. But it is patently nonsense. A much more common fault is found in this sentence:

> In areas of marked topographic differentiation resulting in climatic differences correlated with elevation, [human] seasonal patterns in which temperature is a consideration might be based upon patterns of utilisation of higher elevations in summer and lower elevations in winter (Jelinek, n.d.).

Would much information be lost if one wrote as follows?

> Where difference in altitude markedly affects climate, humans may be expected to use higher areas in summer and lower ones in winter.

A similar problem afflicts this sentence:

> None of these [the distribution of archaeological remains] can be understood, however, without taking into account the ecological nature of the habitat exploited by the toolmakers and it is especially important for the prehistorian to know what main plant and animal resources were present and so available for use by the hunting/gathering populations during the Pleistocene when the biomes may often have differed significantly from those of the present day in response to fluctuations in humidity and temperature. (Clark, 1975: 606)

It could be re-written to read:

> None of these, however, can be understood without taking account of the toolmakers' habitats. It is especially important for the prehistorian to know what plant and animal resources were available to Pleistocene hunter/gatherers. These resources may often have differed significantly from those now present in the same area, since they are drawn from biomes that respond to fluctuations in humidity and temperature.

Similar examples can be found in almost any report—including my own! It is a great temptation to wrap up a truism in convoluted language, or even just to be long-winded. Simple writing makes it apparent to your reader whether you have actually written anything worth reading.

Writing simply is not easy. What is easy to read has usually been difficult to write. You will almost certainly need to write two or three drafts of any report or paper before your work is organised properly and your thoughts are clearly expressed. Pearls of any kind are always the product of slow processes.

(3) When you have to write a report it is often useful to *begin at the end*. First outline your conclusions and recommendations, for then you will have a guide as to what must go into the body of the report—and what must be left out! Next, write an abstract or outline, a half-page summary of the aims, methods, results and conclusions. Then you are ready to write the report in full, starting at the beginning. Proceeding in this way will get you over the most common writer's block—the 'threshold complex', or 'I can't write the first sentence'. The first step is always the hardest, but if the road ahead is clearly marked, it is usually much easier to start your way along it. Finally, when you are faced with writing the first draft, just *write* it. Do not worry at this stage about crafting each sentence and section into a perfect jewel (2b above). The time for that is later. Concentrate *first* on getting everything you can onto paper.

(4) In your *second* draft pay especial attention to the *first section* of your report. This is where a reader will start, so give him a good impression. It is also, in my experience as editor, usually the worst part of any report, loaded with irrelevant generalities, references to unnecessary literature and inappropriate personal background to the work.

This section should contain the *aims* of your report and perhaps a review of the current situation when you began work. Re-read it carefully. Are the aims you have outlined covered by the contents of your report? Are they clearly stated in appropriate language? Is the review comprehensive *and* comprehensible, with each aspect clearly identified? Do the aims relate to the conclusions? In short, does your first section tell a reader where he is going? If it does not, re-write it.

The form of an introduction will vary and will depend on the nature of the report. The introduction to a straightforward excavation or survey may simply outline the circumstances under which it occurred and the objectives of this report (see, for instance, Wainwright, 1972; Victoria Archaeological Survey, n.d. [1977] ). Scientific studies directed towards a particular problem—conditions of cultural and economic growth in the Bronze Age of central Italy (Barker, 1972); are fabricators just used-up cores? (White, 1968)—require an introduction identifying the current state of the problem and the way your researches fit into it. The exact phrasing will, of course, depend on the audience you are writing for (1 above).

(5) When you have written a second, third or fourth draft, and think that your report would now be acceptable to its intended readership, try it out on a few colleagues who are also friends. Select them carefully because they should be good writers themselves as well as people who will actually read your draft sentence by sentence and section by section, and tell you what is wrong with it. But be warned! Your reaction to this experience will be *hostile*. It will be like being told you do not drive a car very well. As your 'friend' reorganises sections, alters paragraph and sentence order, asks you what you mean by this word and that phrase, you will find yourself defending each comma as if your entire career swung on it. It does not. So listen to—or read—the comments, put the report away for a few days and then work through it again. It is amazing how right your friends usually are.

Finally, if you have time, put away your 'final' draft for at least three weeks and then re-read it. Many horriblenesses you have overlooked will leap out of the page at you, and can be corrected.

(6) As with riding a bicycle or recognising stratigraphy, keeping in practice is the best way to maintain your writing skills. The more you write, the easier it becomes. The more you and your friends look critically at what you write, the better your writing will become. Everyone's writing can be improved and, as with any sport, constant training is the only guaranteed method of doing it.

## REPORT WRITING: ARCHAEOLOGICAL

There is only one comprehensive study on archaeological reporting (Grinsell, Rahtz & Williams, 1974) and this is based on the assumption that archaeologists should publish their work fully, in as much detail as possible, in a permanent form, available to anyone who wants to read it in a good library (1974: 18). Despite this limitation, and the fact that the book is primarily directed at English writers who are

reporting excavations, it is a very useful guide to intending reporters. It covers the form and organisation of reports, the contents of excavation and survey reports, including text and illustrations, the use of maps and the form and mechanics of publication. Archaeological reports range from straightforward accounts of survey, excavation or classificatory work, to scientific research papers dealing with a particular problem. While all kinds of reports can be written according to the basic principles outlined in the previous section, there will obviously be differences in content and emphasis between the various kinds of report. In deciding what goes into an archaeological report, you must keep in mind not only the question 'Who is my readership?' but also the archaeologist's obligation to report on the material collected or destroyed in the course of research. You may end up writing several reports, each for a different purpose.

I quote my own experience as an example. In 1971, a group of students and I excavated a small rockshelter which seemed to be endangered by road-widening in an outer Sydney suburb. The first report outlined the objectives and excavation methods, described the various features and artefacts, and made some comparisons with other material from the same area. The report was filed with the National Parks and Wildlife Service and remains unpublished. However, the report and the material are available for any students of Sydney's prehistory. A later report took one class of objects (backed blades) and used the study of them to enter a current discussion in the literature concerning their classification (White & Wieneke, 1973). A detailed account of the site and its contents would have been out of place in the second report; the theoretical discussion was unnecessary—though permissible—in the first.

It is in writing reports of the first kind that authors often overlook some necessary data. The following is a checklist of material which should normally be included (see also Victoria Archaeological Survey, n.d. [1977]; Grinsell, Rahtz & Williams, 1974).

(1) The location of the study area and/or sites given in the form of grid references to the particular map series used by the archaeological survey or equivalent body in your state. In the interests of site protection you may not always want to make locations public but they must be on file somewhere, otherwise they may be lost if an accident befalls you. Any site number or other designation allocated by the state should also be given.

(2) Known data on the environment of the site or region. This may include the prehistoric environment and its changes. There may be more or less detail depending on the nature of the report but some reference to this material is essential in most circumstances.

(3) If a survey or series of excavations is being reported I advise you to describe the material observed or recovered from each site *as a unit*. This is the usual British and Australian practice and it has the advantage of allowing a reader to envisage the relations between classes of material as they were observed rather than having to reconstruct this (see, e.g., Lampert, 1971; White, 1972). The alternative, to describe the structure and stratigraphy of each site and then to describe and discuss finds of each type from the various sites together, is the common American practice (see, e.g., Suggs, 1961; Gifford & Shutler, 1956; Byers, 1967–72). Choosing between the two is partly a matter of personal preference, though the nature of your readership and their experience should always be remembered.

Whichever method of reporting you choose, always write so that the reader can work out which objects come from what site or level. Nothing is more inimical to future use of your work than failure to observe this rule. It is, for example, nearly impossible to discover the precise location of supposed Japanese pottery in Peruvian coastal sites because of poor reporting (Lyon, 1972–4; see also Meggers, Evans & Estrada, 1965). Anyone who has tried to use nearly any site report on the European Palaeolithic will also be aware of the problem. There are, however, many good reports. Within Australia, Hale & Tindale's original report on Devon Downs (1930) is excellent, as is Lampert's on the Durras North site (1966).

(4) Maps, plans of the site and, if excavations have been made, plans and sections of these. See Grinsell, Rahtz & Williams (1974, chapter 3) for basic directions. A *scale* must *always* be included.

(5) A list of finds and some illustration of them. The form of this list may vary. For example, one would not normally individually list 2387 flakes from a test excavation, but some form of catalogue is necessary. When cataloguing material, specify the *reference* for your classifications. If your terminology of pot shapes follows Shepard (1956), say so. If your classification of stone artefacts follows McCarthy, Bramell & Noone (1946), but you have elaborated or modified certain parts of it, say how you have done this. This is important. If it is not clear on what basis you have classified material, your readers may easily misinterpret your findings, especially if you have used common names for your classes. This applies to all kinds of finds (such as bones) and not just to implements.

(6) The present location and planned disposition of the finds and records, and of copies of the latter. A simple sentence is adequate and will save future researchers and museum curators much unnecessary work.

(7) Acknowledgements to all field and laboratory assistants and to any financial supporters. Courtesy in this matter needs no justification.

## WRITING FOR PUBLICATION: THE TWENTY-NINE STEPS

In their clear, concise and helpful book, *Writing Scientific Papers in English* (1975), O'Connor & Woodford list twenty-nine steps in the preparation of a paper for publication. Twenty-seven of these occur before submitting it to an editor. Following their advice, of course, will not ensure that what you write will be acceptable for publication, but it will ensure that your manuscript is seriously considered by an editor.

Some of the steps involve general matters I have mentioned already. Some other steps apply specifically to authors writing for publication and, since these are often overlooked or ignored, I re-iterate them here.

(1) Obtain *and read* the instructions to authors of the journal you have chosen. These instructions range from being very specific (e.g., *Science*) to quite general, but each journal has its own style and format, which you should follow. Instructions to authors cover such matters as acceptable length of articles, required format (number of copies, paper type and size, where to put notes and acknowledgements, etc.), bibliographic style including form of abbreviations to be used, nature and size of acceptable illustrations, and so on. Failure to comply with the instructions will often result in your paper being returned—unread.

(2) Design tables, including their titles, and select illustrations and maps and write their legends while you are writing the paper. These graphics may be only rough drafts but it is important to decide early what is to be tabulated or illustrated rather than described in the text. Graphs, tables and illustrations should *not* duplicate text

material. Each picture should save a thousand words (more or less!).

Also, remember that illustrations should be *essential* to your paper. For example, a note reporting a radiocarbon date for a skeleton buried in a sand dune is not likely to *need* a picture of the dune or a close-up of the skeleton during excavation. It might require a drawn stratigraphic section. Essential illustrations are those which elucidate key, difficult points in your paper. Be ruthless in their selection!

(3) When you make up final copies of graphics, bear four things in mind:

(a) Your aim must be to produce balanced, clear and aesthetically pleasing graphs and illustrations and clear, clean tables.

(b) Most graphics will be printed smaller than they are drawn. Reduction may be to *one-quarter* or less of the original area of your drawing. This means that the thickness of lines and the size of lettering must be greater than you think. Seek advice from an experienced person or the editor. Otherwise you may have to re-draw everything.

(c) Draw graphics and tables and choose photographs so that when reduced they will fit well onto a page or in a column of the journal. If the width of type on a page is 150 mm, draw your graphic 300 mm wide and the appropriate depth.

(d) The captions to your illustrations should draw attention to the critical features, concisely and simply. Say of a map 'Eastern Melanesia showing sites discussed (•) and Austronesian language areas (+)' not 'Map of the islands of Eastern Melanesia with locations of sites discussed in the text (black dots) and areas where Austronesian languages are spoken (crosses)'. For a graph, there is no need to say 'Graph of . . .'; start with the basic words.

(4) Make sure your documentation is accurate. This is hard work. *Do not* trust your memory, even in citing your own writings. *Check* the title of every reference, every year, volume and page number. Inaccuracy of citation is one of the most common faults in all scientific writing—and one of the most annoying. The reference omitted or wrongly given in someone else's paper is always the one you want! Do not do it to others.

Your bibliography should contain all and only those items referred to in your paper, and it should follow *precisely* the style chosen by the journal to which your paper is submitted. This includes details such as capitalisation of names, punctuation, abbreviations and so on. If your journal wants references to other journals in a specific form—usually the American or British standard for the abbreviation of titles of periodicals (American Chemistry Society, 1970; British Standards Institution, 1970)—look these up. Do not guess. If these standards, or instructions to authors, do not cover a specific problem, look at recent issues of the journal.

(5) Australia is now scientifically metric. Therefore you should give all measurements in SI (Système International d'Unités) units, and use world standard abbreviations. The basic SI units of linear measurement are metres (m) and millimetres (mm) and it is these that are now used by most scientific disciplines. The use of centimetres (cm) is not a crime, but does not conform to standard scientific practice. Other basic units are grams (g not gm) and cubic centimetres ($cm^3$ not c.c.).

(6) When your article has been accepted and set in type it will be returned to you for proof-reading. Proof-reading is to allow you to correct *the printer's mistakes*. It is too late to correct your own! The cost of alterations is so high that only if you pay for them will most journals permit you to make alterations or to correct your English.

Proof corrections should be made clearly and use the standard symbols. Such symbols are given in the appendix at the end of this chapter.

## CONCLUSIONS

Archaeologists destroy the record of the past by the very act of their discovery of it. Therefore, more than most scientists, they have the obligation to report their destructive activities accurately. This involves careful planning of reports and clear writing in them. Attention to both these aspects and to the relevant details will always allow you to communicate effectively with the appropriate readership.

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## APPENDIX

### Symbols for correcting proofs

(from *Style Manual for Authors, Editors and Printers*, 3rd ed. Canberra, 1978, reprinted by kind permission of the Australian Government Publishing Service.)

## SYMBOLS FOR CORRECTING PROOFS

| *No.* | *Instruction* | *Textual mark* | *Marginal mark** |
|---|---|---|---|
| 1 | Correction is concluded | None | / |
| 2 | Insert in text the matter indicated in margin | ⋏ | *New matter followed by* / |
| 3 | Delete | Strike through characters to be deleted | δ/ |
| 4 | Delete and close up | ⌒/ above and below letters to be taken out | ₍δ/₎ |
| 5 | Leave as printed | . . . . under characters to remain | stet |
| 6 | Change to italic | ——— under characters to be altered | ital |
| 7 | Change to even small capitals | ═══ under characters to be altered | s.c. |
| 8 | Change to capital letters | ≡≡≡ under characters to be altered | caps |
| 9 | Use capital letters for initial letters and small capitals for rest of words | ≡≡≡ under initial letters and ═══ under the rest of the words | c.& s.c. |
| 10 | Change to bold type | 〰〰 under characters to be altered | bold |
| 11 | Change to lower case | Encircle characters to be altered | l.c. |
| 12 | Change to roman type | Encircle characters to be altered | rom. |
| 13 | Wrong font. Replace by letter of correct font | Encircle character to be altered | w.f. |
| 14 | Invert type | Encircle character to be altered | ꝺ |
| 15 | Change damaged character(s) | Encircle character(s) to be altered | x |
| 16 | Substitute or insert character(s) under which this mark is placed, in 'superior' position | / through character or ⋏ where required | ⅂ *under character* (e.g. ⅂ ) |

* Words printed in italics in column below are instructions and not part of the marks.

| No. | *Instruction* | *Textual mark* | *Marginal mark** |
|---|---|---|---|
| 17 | Substitute or insert character(s) over which this mark is placed, in 'inferior' position | / through character or ⅄ where required | ⅄ *over character* (e.g. x⅄ ) |
| 18 | Underline word or words | —— under words affected | *underline* |
| 19 | Use ligature (e.g. ﬃ) or diphthong (e.g. œ) | ⁀‿ enclosing letters to be altered | ⁀‿ *enclosing ligature or diphthong required* |
| 20 | Substitute separate letters for ligature or diphthong | / through ligature or diphthong to be altered | *write out separate letters followed by* / |
| 21 | Close up—delete space between characters | ⁀‿ linking characters | ⁀‿ |
| 22 | Insert space† | ⅄ | # |
| 23 | Insert space between lines or paragraphs† | > between lines to be spaced | # |
| 24 | Reduce space between lines† | ( ) connecting lines to be closed up | *less* # *or close up* |
| 25 | Make space appear equal between words | \| between words | *eq.* # |
| 26 | Reduce space between words† | \| between words | *less* # |
| 27 | Add space between letters† | \|\|\|\| between tops of letters requiring space | *letter* # |
| 28 | Transpose | ⊓⊔ between characters or words | *trs* |
| 29 | Place in centre of line | Indicate position with [ ] | *centre* |
| 30 | Indent one em | ⊏ | □ |
| 31 | Indent two ems | ⊏ | □□ |
| 32 | Move matter to right | [ at left or right side of group to be moved | [ |
| 33 | Move matter to left | ] at right or left side of group to be moved | ] |

* Words printed in italics in column below are instructions and not part of the marks.
† Amount of space may be indicated.

| *No.* | *Instruction* | *Textual mark* | *Marginal mark* |
|---|---|---|---|
| 34 | Move matter to position indicated | [ ] at limits of required position | *move* |
| 35 | Take over character(s) or line to next line, column or page | ⊏ | *take over* |
| 36 | Take back character(s) or line to previous line, column or page | ⊐ | *take back* |
| 37 | Raise lines* | [line with upward arrow] over lines to be moved<br>[line with raised ends] under lines to be moved | *raise* |
| 38 | Lower lines* | [line with lowered ends] over lines to be moved<br>[line with downward arrow] under lines to be moved | *lower* |
| 39 | Correct the vertical alignment | ‖ | ‖ |
| 40 | Straighten lines | ═ through lines to be straightened | ═ |
| 41 | Push down space | Encircle space affected | ⊥ |
| 42 | Begin a new paragraph | ⊏ before first word of new paragraph | *n.p.* |
| 43 | No fresh paragraph here | [run-on curve] between paragraphs | *run on* |
| 44 | Spell out abbreviation or figure in full | Encircle words or figures to be altered | *spell out* |
| 45 | Insert omitted portion of copy | ⋏ | *out - see copy* |
| 46 | Substitute or insert comma | / through character or ⋏ where required | ,/ |
| 47 | Substitute or insert semicolon | / through character or ⋏ where required | ;/ |
| 48 | Substitute or insert full stop | / through character or ⋏ where required | ⊙ |
| 49 | Substitute or insert colon | / through character or ⋏ where required | (:) |

* Amount of space may be indicated.

| *No.* | *Instruction* | *Textual mark* | *Marginal mark* |
|---|---|---|---|
| 50 | Substitute or insert question mark | / through character or ⋏ where required | ?/ |
| 51 | Substitute or insert exclamation mark | / through character or ⋏ where required | !/ |
| 52 | Insert parentheses | ⋏ or ⋏⋏ | (/ )/ |
| 53 | Insert brackets | ⋏ or ⋏⋏ | [/ ]/ |
| 54 | Insert hyphen | ⋏ | \|-\| |
| 55 | Insert en (half-em) rule | ⋏ | \|-\| with en above |
| 56 | Insert one-em rule | ⋏ | \|—\| with em above |
| 57 | Insert two-em rule | ⋏ | \|——\| with 2em above |
| 58 | Insert apostrophe | ⋏ | '/ |
| 59 | Insert single quotation marks | ⋏ or ⋏⋏ | '/ '/ |
| 60 | Insert double quotation marks | ⋏ or ⋏⋏ | "/ "/ |
| 61 | Insert ellipsis | ⋏ | .../ |
| 62 | Insert leader | ⋏ | circled .. |
| 63 | Insert diagonal stroke | ⋏ | circled / |
| 64 | Refer to appropriate authority anything of doubtful accuracy | Encircle words etc., affected | circled ? |

*Note:* Chapter submitted in 1978.

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